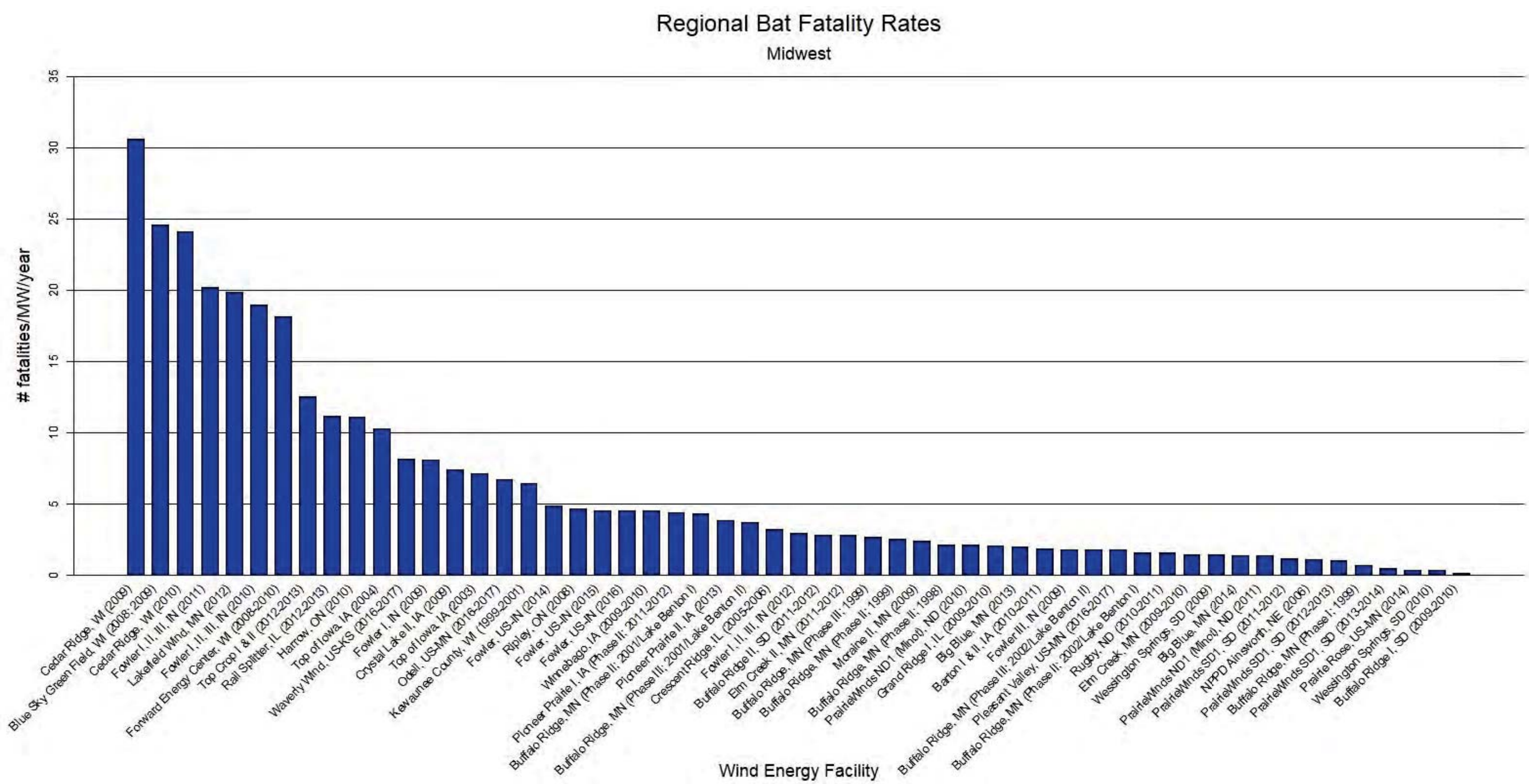

Figure 8. Fatality rates for bats (number of bats per MW per year) from publicly-available studies at wind energy facilities in the Midwest regions of North America.

Figure 8 (*continued*). Fatality rates for bats (number of bats per megawatts per year) from publically available wind energy facilities in the Midwest region of North America. Data from the following sources:

Facility Study	Bat Fatality	Fatality Estimate Citation
Three Waters, MN		**This study**
Cedar Ridge, WI (2009)	30.61	BHE Environ-mental 2010
Blue Sky Green Field, WI (2008; 2009)	24.57	Gruver et al. 2009
Cedar Ridge, WI (2010)	24.12	BHE Environ-mental 2011
Fowler I, II, III, IN (2011)	20.19	Good et al. 2012
Lakefield Wind, MN (2012)	19.87	Minnesota Public Utilities Commission 2012
Fowler I, II, III, IN (2010)	18.96	Good et al. 2011
Forward Energy Center, WI (2008-2010)	18.17	Grodsky and Drake 2011
Top Crop I & II (2012-2013)	12.55	Good et al. 2013c
Rail Splitter, IL (2012-2013)	11.21	Good et al. 2013b
Harrow, Ont (2010)	11.13	Natural Resources Solutions Inc. (NRSI) 2011
Top of Iowa, IA (2004)	10.27	Jain 2005
Waverly Wind, US-KS (2016-2017)	8.2	Tetra Tech 2017a
Fowler I, IN (2009)	8.09	Johnson et al. 2010a
Crystal Lake II, IA (2009)	7.42	Derby et al. 2010b
Top of Iowa, IA (2003)	7.16	Jain 2005
Kewaunee County, WI (1999-2001)	6.45	Howe et al. 2002
Fowler, US-IN (2014)	4.86	Good et al. 2015
Ripley, Ont (2008)	4.67	Jacques Whitford 2009
Fowler, US-IN (2015)	4.54	Good et al. 2016
Fowler, US-IN (2016)	4.54	Good et al. 2017
Winnebago, IA (2009-2010)	4.54	Derby et al. 2010a
Pioneer Prairie I, IA (Phase II; 2011-2012)	4.43	Chodachek et al. 2012
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	4.35	Johnson et al. 2004
Pioneer Prairie II, IA (2013)	3.83	Chodachek et al. 2014
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	3.71	Johnson et al. 2004
Crescent Ridge, IL (2005-2006)	3.27	Kerlinger et al. 2007
Fowler I, II, III, IN (2012)	2.96	Good et al. 2013a
Buffalo Ridge II, SD (2011-2012)	2.81	Derby et al. 2012a
Elm Creek II, MN (2011-2012)	2.81	Derby et al. 2012b
Buffalo Ridge, MN (Phase III; 1999)	2.72	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1999)	2.59	Johnson et al. 2000
Moraine II, MN (2009)	2.42	Derby et al. 2010f
Buffalo Ridge, MN (Phase II; 1998)	2.16	Johnson et al. 2000
PrairieWinds ND1 (Minot), ND (2010)	2.13	Derby et al. 2011d
Grand Ridge I, IL (2009-2010)	2.1	Derby et al. 2010a
Big Blue, MN (2013)	2.04	Fagen Engineering 2014
Barton I & II, IA (2010-2011)	1.85	Derby et al. 2011b
Fowler III, IN (2009)	1.84	Johnson et al. 2010b
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.81	Johnson et al. 2004
Pleasant Valley, US-MN (2016-2017)	1.8	Tetra Tech 2017b
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.64	Johnson et al. 2004
Rugby, ND (2010-2011)	1.6	Derby et al. 2011c
Elm Creek, MN (2009-2010)	1.49	Derby et al. 2010e
Wessington Springs, SD (2009)	1.48	Derby et al. 2010c
Big Blue, MN (2014)	1.43	Fagen Engineering 2015
PrairieWinds ND1 (Minot), ND (2011)	1.39	Derby et al. 2012d

Figure 8 (*continued*). Fatality rates for bats (number of bats per megawatts per year) from publically available wind energy facilities in the Midwest region of North America. Data from the following sources:

Facility Study	Bat Fatality	Fatality Estimate Citation
Three Waters, MN		**This study**
PrairieWinds SD1, SD (2011-2012)	1.23	Derby et al. 2012c
NPPD Ainsworth, NE (2006)	1.16	Derby et al. 2007
PrairieWinds SD1, SD (2012-2013)	1.05	Derby et al. 2013a
Buffalo Ridge, MN (Phase I; 1999)	0.74	Johnson et al. 2000
PrairieWinds SD1, SD (2013-2014)	0.52	Derby et al. 2014
Prairie Rose, US-MN (2014)	0.41	Chodachek et al. 2015
Wessington Springs, SD (2010)	0.41	Derby et al. 2011a
Buffalo Ridge I, SD (2009-2010)	0.16	Derby et al. 2010d

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Appendix A: North American Fatality Summary Tables

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region.

Wind Energy Facility	Bat Activity Estimate[A]	Bat Activity Dates	Fatality Estimate[B]	No. of Turbines	Total MW
Three Waters, MN	**4.72**	7/31/17-10/14/17			
Southwest					
Dry Lake, AZ	8.8	4/29/10-11/10/10	4.29	30	63
Southern Plains					
Barton Chapel, TX			3.06	60	120
Buffalo Gap II, TX			0.14	155	233
Buffalo Gap I, TX			0.1	67	134
California					
Shiloh I, CA			3.92	100	150
High Winds, CA (2004)			2.51	90	162
Dillon, CA			2.17	45	45
High Winds, CA (2005)			1.52	90	162
Alite, CA			0.24	8	24
Pacific Northwest					
Biglow Canyon, OR (Phase II; 2009/2010)			2.71	65	150
Nine Canyon, WA			2.47	37	48.1
Stateline, OR/WA 2003			2.29	454	263
Biglow Canyon, OR (Phase I; 2008)			1.99	76	125.4
Leaning Juniper, OR			1.98	67	100.5
Big Horn, WA			1.90	133	199.5
Combine Hills, OR			1.88	41	41
Pebble Springs, OR			1.55	47	98.7
Hopkins Ridge, WA (2008)			1.39	87	156.6
Elkhorn, OR (2008)			1.26	61	101
Vansycle, OR			1.12	38	24.9
Klondike III, OR			1.11	122	375
Stateline, OR/WA 2002			1.09	454	263
Tuolumne (Windy Point I), WA			0.94	62	136.6
Klondike, OR			0.77	16	24
Hopkins Ridge, WA (2006)			0.63	83	150
Biglow Canyon, OR (Phase I; 2009)			0.58	76	125.4
Hay Canyon, OR			0.53	48	100.8
Klondike II, OR			0.41	50	75
Wild Horse, WA			0.39	127	229
Goodnoe, WA			0.34	47	94
Marengo II, WA (2009)			0.27	39	70.2
Marengo I, WA (2009)			0.17	39	70.2
Klondike IIIa, OR			0.16	125	375
Rocky Mountains					
Summerview, Alb. (2008)	7.7 [D]	07/15/06-07-09/30/06-07	11.42	39	70.2
Judith Gap, MT			8.93	90	135
Foote Creek Rim, WY (Phase I; 1999)			3.97	69	41.4
Foote Creek Rim, WY (Phase I; 2001-2002)	2.2 [D,E]	6/15/01-9/1/01	1.57	69	41.4
Foote Creek Rim, WY (Phase I; 2000)	2.2 [D,E]	6/15/00-9/1/00	1.05	69	41.4

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region.

Wind Energy Facility	Bat Activity Estimate[A]	Bat Activity Dates	Fatality Estimate[B]	No. of Turbines	Total MW
		Midwest			
Cedar Ridge, WI (2009)	10.0 [C,E,F]	7/16/07-9/30/07	30.61	41	67.6
Blue Sky Green Field, WI	7.7 [F]	7/24/07-10/29/07	24.57	88	145
Cedar Ridge, WI (2010)	10.0 [C,E,F]	7/16/07-09/30/07	24.12	41	68
Forward Energy Center, WI	6.97	8/5/08-11/08/08	18.17	86	129
Top of Iowa, IA (2004)	35.7	5/26/04-9/24/04	10.27	89	80
Crystal Lake II, IA			7.42	80	200
Top of Iowa, IA (2003)			7.16	89	80
Kewaunee County, WI			6.45	31	20.46
Ripley, Ont. (2008)			4.67	38	76
Winnebago, IA			4.54	10	20
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	2.2 [D]	6/15/01-9/15/01	4.35	143	107.25
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	2.2 [D]	6/15/01-9/15/01	3.71	138	103.5
Crescent Ridge, IL			3.27	33	54.45
Buffalo Ridge, MN (Phase III; 1999)			2.72	138	103.5
Buffalo Ridge, MN (Phase II; 1999)			2.59	143	107.25
Morraine II, MN			2.42	33	49.5
Buffalo Ridge, MN (Phase II; 1998)			2.16	143	107.25
Prairie Winds (Minot), ND			2.13	80	115.5
Grand Ridge, IL			2.10	66	99
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.9 [D]	6/15/02-9/15/02	1.81	138	103.5
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.9 [D]	6/15/02-9/15/02	1.64	143	107.25
Elm Creek, MN			1.49	67	100
Wessington Springs, SD			1.48	34	51
NPPD Ainsworth, NE			1.16	36	20.5
Buffalo Ridge, MN (Phase I; 1999)			0.74	73	25
Buffalo Ridge I, SD (2010)			0.16	24	50.4
		Southeast			
Buffalo Mountain, TN (2005)			39.70	18	28.98
Buffalo Mountain, TN (2000-2003)	23.7 [E]		31.54	3	1.98

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region.

Wind Energy Facility	Bat Activity Estimate[A]	Bat Activity Dates	Fatality Estimate[B]	No. of Turbines	Total MW
		Northeast			
Mountaineer, WV	38.3 [E]	8/1/04-9/14/04	31.69	44	68
Mount Storm, WV (2009)	30.09	7/15/09-10/7/09	24.32	132	264
Mount Storm, WV (2010)	44.12	4/18/10-10/15/10	15.18	132	264
Casselman, PA (Spring & Fall 2008)			12.61	23	34.5
Maple Ridge, NY (2006)			11.21	120	198
Maple Ridge, NY (2007)			9.42	195	321.75
Cohocton/Dutch Hill, NY (2009)			8.62	50	125
Noble Bliss, NY (2008)			7.80	67	100
Mount Storm, WV (Fall 2008)	35.2	7/20/08-10/12/08	6.62	82	164
Wolfe Island, Ont (July-December 2009)			6.42	86	197.8
Maple Ridge, NY (2008)			4.96	195	321.75
Noble Clinton, NY (2009)	1.9 [C]	8/1/09-09/31/09	4.50	67	100
Noble Ellenburg, NY (2009)	16.1 [C]	8/16/09-09/15/09	3.91	54	80
Noble Bliss, NY (2009)			3.85	67	100
Lempster, NH (2010)			3.57	12	24
Noble Ellenburg, NY (2008)			3.46	54	80
Noble Clinton, NY (2008)	2.1 [C]	8/8/08-09/31/08	3.14	67	100
Lempster, NH (2009)			3.11	12	24
Mars Hill, ME (2007)			2.91	28	42
Munnsville, NY (2008)			1.93	23	34.5
Stetson Mountain, ME (2009)	28.5; 0.3[G]	7/10/09-10/15/09	1.40	38	57
Mars Hill, ME (2008)			0.45	28	42

A = Bat passes per detector-night
B = Number of fatalities per megawatt per year
C = Activity rate based on data collected at various heights all other activity rates are from ground-based units only
D = Activity rate was averaged across phases and/or years
E = Activity rate calculated by WEST from data presented in referenced report
F= Activity rate based on pre-construction monitoring; data for all other activity and fatality rates were collected concurrently
G = The overall activity rate of 28.5 is from reference stations located along forest edges which may be attractive to bats; the activity rate of 0.3 is from one unit placed on a nacelle

Appendix A1 (*continued*). Wind energy facilities in North America with comparable fatality data for bats.

Project, Location	Activity Reference	Fatality Reference	Project, Location	Activity Reference	Fatality Reference
Alite, CA		Chatfield et al. 2010	Klondike II, OR		NWC and WEST 2007
Barton Chapel, TX		WEST 2011	Klondike III, OR		Gritski et al. 2009a
Big Horn, WA		Kronner et al. 2008	Klondike IIIa, OR		Gritski et al. 2009b
Biglow Canyon, OR (Phase I; 08)		Jeffrey et al. 2009a	Leaning Juniper, OR		Kronner et al. 2007
Biglow Canyon, OR (Phase I; 09)		Enk et al. 2010	Lempster, NH (09)		Tidhar et al. 2010
Biglow Canyon, OR (Phase II; 09/10)		Enk et al. 2011	Lempster, NH (09)		Tidhar et al. 2011
Blue Sky Green Field, WI	Gruver 2008	Gruver et al. 2009	Maple Ridge, NY (06)		Jain et al. 2007
Buffalo Mountain, TN (00-03)	Fiedler 2004	Nicholson et al. 2005	Maple Ridge, NY (07)		Jain et al. 2008
Buffalo Mountain, TN (05)		Fiedler et al. 2007	Maple Ridge, NY (08)		Jain et al. 2009c
Buffalo Ridge, MN (Phase I; 99)		Johnson et al. 2000	Marengo I, WA (09)		URS Corporation 2010b
Buffalo Ridge, MN (Phase II; 98)		Johnson et al. 2000	Marengo II, WA (09)		URS Corporation 2010c
Buffalo Ridge, MN (Phase II; 99)		Johnson et al. 2000	Mars Hill, ME (07)		Stantec 2008
Buffalo Ridge, MN (Phase II; 01/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Mars Hill, ME (08)		Stantec 2009a
Buffalo Ridge, MN (Phase II; 02/Lake Benton I)	Johnsonet al. 2004	Johnson et al. 2004	Moraine II, MN		Derby et al. 2010d
Buffalo Ridge, MN (Phase III; 99)		Johnson et al. 2000	Mount Storm, WV (Fall 08)	Young et al. 2009a	Younget al. 2009a
Buffalo Ridge, MN (Phase III; 01/Lake Benton II)	Johnsonet al. 2004	Johnson et al. 2004	Mount Storm, WV (09)		Young et al. 2009b, 2010a
Buffalo Ridge, MN (Phase III; 02/Lake Benton II)	Johnsonet al. 2004	Johnson et al. 2004	Mount Storm, WV (10)		Young et al. 2010b, 2011
Buffalo Ridge I, SD		Derby et al. 2010b	Mountaineer, WV	Arnett et al. 2005, Arnett pers. comm.	Arnettet al. 2005
Casselman, PA (Spring and Fall 08)		Arnett et al. 2009	Munnsville, NY		Stantec 2009b
Cedar Ridge, WI (09)	BHE Environmental 2008	BHE Environmental 2010	Nine Canyon, WA		Erickson et al. 2003b
Cedar Ridge, WI (10)	BHE Environmental 2008	BHE Environmental 2011	Noble Bliss, NY (08)		Jain et al. 2009d
Cohocton/Dutch Hill, NY		Stantec 2010	Noble Bliss, NY (09)		Jain et al. 2010a
Combine Hills, OR		Young et al. 2006	Noble Clinton, NY (08)		Jain et al. 2009b
Crescent Ridge, IL		Kerlinger et al. 2007	Noble Clinton, NY (09)		Jain et al. 2010b
Crystal Lake II, IA		Derby et al. 2010a	Noble Ellenburg, NY (08)		Jain et al. 2009a
Dillon, CA		Chatfield et al. 2009	Noble Ellenburg, NY (09)		Jain et al. 2010c
Dry Lake, AZ	Thompson et al. 2011	Thompsonet al. 2011	NPPD Ainsworth, NE		Derby et al. 2007
Elkhorn, OR		Jeffrey et al. 2009b	Pebble Springs, OR		Gritski and Kronner 2010b
Elm Creek, MN		Derby et al. 2010c	Prairie Winds (Minot), ND		Derby et al. 2011
Foote Creek Rim, WY (Phase I; 99)		Young et al. 2003	Ripley, Ont. (08)		Jacques Whitford 2009
Foote Creek Rim, WY (Phase I; 00)	Gruver 2002	Younget al. 2003	Shiloh I. CA		Kerlinger et al. 2010
Foote Creek Rim, WY (Phase I; 01-02)		Younget al. 2003	Stateline, OR/WA (02)		Erickson et al. 2004
Forward Energy Center, WI		Grodsky and Drake 2011	Stateline, OR/WA (03)		Ericksonet al. 2004
Goodnoe, WA		URS Corporation 2010a	Stetson Mountain, ME	Stantec 2009c	Stantec 2009c

Appendix A1 (*continued*). Wind energy facilities in North America with comparable fatality data for bats.

Project, Location	Activity Reference	Fatality Reference	Project, Location	Activity Reference	Fatality Reference
Grand Ridge, IL		Derby et al. 2010g	Summerview (08)	Baerwald 2008	Baerwald 2008
Hay Canyon, OR		Gritski and Kronner 2010a	Top of Iowa, IA (03)		Jain 2005
High Winds, CA (04)		Kerlinger et al. 2006	Top of Iowa, IA (04)	Jain 2005	Jain 2005
High Winds, CA (05)		Kerlinger et al. 2006	Tuolumne (Windy Point I), WA		Enz and Bay 2010
Hopkins Ridge, WA (06)		Young et al. 2007	Vansycle, OR		Erickson et al. 2000
Hopkins Ridge, WA (08)		Young et al. 2009c	Wessington Springs, SD		Derby et al. 2010f
Judith Gap, MT		TRC 2008	Wild Horse, WA		Erickson et al. 2008
Kewaunee County, WI		Howe et al. 2002	Winnebago, IA		Derby et al. 2010e
Klondike, OR		Johnson et al. 2003	Wolfe Island, Ont. (July-Dec. 09)		Stantec Ltd. 2010b

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Alite, CA (2009-2010)	0.24	shrub/scrub & grassland	Chatfield et al. 2010
Alta I, CA (2013-2014)	0.36	Grassland;Shrub Steppe	Chatfield et al. 2014
Alta I, CA (2015-2016)	0.7	Grassland;Shrub Steppe	Thompson et al. 2016a
Alta II-V, CA (2013-2014)	0	Grassland;Shrub Steppe	Chatfield et al. 2014
Alta II-V, CA (2015-2016)	0	Grassland;Shrub Steppe	Thompson et al. 2016a
Alta VIII, CA (2012-2013)	0	grassland and riparian	Chatfield and Bay 2014
Alta VIII, CA (2014-2015)	0.17	Desert Creosote;Grassland;Joshua Tree	Western EcoSystems Technology, Inc. (WEST) 2016c
Alta Wind I, CA (2011-2012)	1.28	woodland, grassland, shrubland	Chatfield et al. 2015
Alta Wind II-V, CA (2011-2012)	0.08	desert scrub	Thompson et al. 2016b
Alta X, CA (2014-2015)	0.42	Forest/Woodlot;Shrub Steppe	Chatfield et al. 2012
Alta X, CA (2015-2016)	0.8	Shrub Steppe	Chatfield et al. 2012
Barton Chapel, TX (2009-2010)	3.06	agriculture/forest	WEST 2011
Barton I & II, IA (2010-2011)	1.85	agriculture	Derby et al. 2011b
Beech Ridge, WV (2012)	2.03	forest	Tidhar et al. 2013a
Beech Ridge, WV (2013)	0.58	forest	Young et al. 2014a
Big Blue, MN (2013)	2.04	agriculture	Fagen Engineering 2014
Big Blue, MN (2014)	1.43	agriculture	Fagen Engineering 2015
Big Horn, WA (2006-2007)	1.9	agriculture/grassland	Kronner et al. 2008
Big Smile, OK (2012-2013)	2.9	grassland, agriculture	Derby et al. 2013b
Biglow Canyon, OR (Phase I; 2008)	1.99	agriculture/grassland	Jeffrey et al. 2009b
Biglow Canyon, OR (Phase I; 2009)	0.58	agriculture/grassland	Enk et al. 2010
Biglow Canyon, OR (Phase II; 2009-2010)	2.71	agriculture	Enk et al. 2011b
Biglow Canyon, OR (Phase II; 2010-2011)	0.57	grassland/shrub-steppe, agriculture	Enk et al. 2012b
Biglow Canyon, OR (Phase III; 2010-2011)	0.22	grassland/shrub-steppe, agriculture	Enk et al. 2012a
Bingham Wind Project, ME (2017)	0.23	Bermuda Grass/Mixed Grasses;Clover;Road and Pad	TRC 2017a
Blue Sky Green Field, WI (2008; 2009)	24.57	agriculture	Gruver et al. 2009
Buffalo Gap I, TX (2006)	0.1	grassland	Tierney 2007
Buffalo Gap II, TX (2007-2008)	0.14	forest	Tierney 2009
Buffalo Mountain, TN (2000-2003)	31.54	forest	Nicholson et al. 2005

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Buffalo Mountain, TN (2005)	39.7	forest	Fiedler et al. 2007
Buffalo Ridge I, SD (2009-2010)	0.16	agriculture/grassland	Derby et al. 2010d
Buffalo Ridge II, SD (2011-2012)	2.81	agriculture, grassland	Derby et al. 2012a
Buffalo Ridge, MN (Phase I; 1999)	0.74	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1998)	2.16	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1999)	2.59	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	4.35	agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.64	agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 1999)	2.72	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	3.71	agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.81	agriculture	Johnson et al. 2004
Bull Hill, ME (2013)	1.62	forest	Stantec Consulting, Inc. (Stantec) 2014a
Cameron Ridge/Section 15, CA (2014-2015)	0.15	Shrub Steppe	WEST 2016b
Cameron Ridge/Section 15, CA (2015-2016)	0.19	Shrub Steppe	Rintz and Thompson 2017
Casselman Curtailment, PA (2008)	4.4	forest	Arnett et al. 2009a
Casselman, PA (2008)	12.61	forest	Arnett et al. 2009b
Casselman, PA (2009)	8.6	forest, pasture, grassland	Arnett et al. 2010
Cedar Ridge, WI (2009)	30.61	agriculture	BHE Environmental 2010
Cedar Ridge, WI (2010)	24.12	agriculture	BHE Environmental 2011
Chopin, OR (2016-2017)	1.9	Agriculture	Hallingstad and Riser-Espinoza 2017
Cohocton/Dutch Hill, NY (2009)	8.62	agriculture/forest	Stantec 2010
Cohocton/Dutch Hill, NY (2013)	1.37	Agriculture;Forest/Woodlot	Stantec 2014b
Cohocton/Dutch Hills, NY (2010)	10.32	agriculture/forest	Stantec 2011a
Combine Hills, OR (2011)	0.73	grassland/shrub-steppe, agriculture	Young et al. 2006
Combine Hills, OR (Phase I; 2004-2005)	1.88	agriculture/grassland	Enz et al. 2012
Crescent Ridge, IL (2005-2006)	3.27	agriculture	Kerlinger et al. 2007
Criterion, MD (2011)	15.61	forest, agriculture	Young et al. 2012b

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Criterion, MD (2012)	7.62	forest, agriculture	Young et al. 2013
Criterion, MD (2013)	5.32	forest, agriculture	Young et al. 2014b
Crystal Lake II, IA (2009)	7.42	agriculture	Derby et al. 2010b
Diablo Winds, CA (2005-2007)	0.82		WEST 2006, 2008
Dillon, CA (2008-2009)	2.17	desert	Chatfield et al. 2009
Dry Lake I, AZ (2009-2010)	3.43	desert grassland/forested	Thompson et al. 2011
Dry Lake II, AZ (2011-2012)	1.66	desert grassland/forested	Thompson and Bay 2012
Elkhorn, OR (2008)	1.26	shrub/scrub & agriculture	Jeffrey et a. 2009a
Elkhorn, OR (2010)	2.14	shrub/scrub & agriculture	Enk et al. 2011a
Elm Creek II, MN (2011-2012)	2.81	agriculture, grassland	Derby et al. 2010e
Elm Creek, MN (2009-2010)	1.49	agriculture	Derby et al. 2012b
Foote Creek Rim I, WY (1999)	3.97	grassland	Young et al. 2003
Foote Creek Rim I, WY (2000)	1.05	grassland	Young et al. 2003
Foote Creek Rim I, WY (2001-2002)	1.57	grassland	Young et al. 2003
Forward Energy Center, WI (2008-2010)	18.17	agriculture	Grodsky and Drake 2011
Fowler I, II, III, IN (2010)	18.96	agriculture	Good et al. 2011
Fowler I, II, III, IN (2011)	20.19	agriculture	Good et al. 2012
Fowler I, II, III, IN (2012)	2.96	agriculture	Good et al. 2013a
Fowler I, IN (2009)	1.84	agriculture	Johnson et al. 2010a
Fowler III, IN (2009)	1.84	agriculture	Johnson et al. 2010b
Fowler, IN (2014)	3.84	Agriculture;Developed	Good et al. 2015
Fowler, IN (2015)	4.86	Agriculture;Developed	Good et al. 2016
Fowler, IN (2016)	4.54	Agriculture;Developed	Good et al. 2017
Goodnoe, WA (2009-2010)	0.34	grassland and shrub-steppe	URS Corporation (URS) 2010a
Grand Ridge I, IL (2009-2010)	2.1	agriculture	Derby et al. 2010a
Groton, NH (2013)	1.31	Forest/Woodlot	Stantec and WEST 2014
Groton, NH (2014)	1.63	Forest/Woodlot	Stantec and WEST 2015a
Groton, NH (2015)	1.74	Forest/Woodlot	Stantec and WEST 2015b
Hancock, ME (2017)	0.3	Clover;Gravel;Road and Pad	TRC 2017b
Harrow, Ont (2010)	11.13	agriculture	Natural Resource Solutions Inc. (NRSI) 2011
Harvest Wind, WA (2010-2012)	1.27	grassland/shrub-steppe	Downes and Gritski 2012a
Hatchet Ridge, CA (2011)	2.23	Forest/Woodlot	Tetra Tech 2013
Hatchet Ridge, CA (2012-2013)	5.22	Forest/Woodlot	Tetra Tech 2013

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Hatchet Ridge, CA (2012)	4.2		Tetra Tech 2014
Hay Canyon, OR (2009-2010)	0.53	agriculture	Gritski and Kronner 2010a
High Sheldon, NY (2010)	2.33	agriculture	Tidhar et al. 2012a
High Sheldon, NY (2011)	1.78	agriculture	Tidhar et al. 2012b
High Winds, CA (2003-2004)	2.51	agriculture/grassland	Kerlinger et al. 2006
High Winds, CA (2004-2005)	1.52	agriculture/grassland	Kerlinger et al. 2006
Hopkins Ridge, WA (2006)	0.63	agriculture/grassland	Young et al. 2007
Hopkins Ridge, WA (2008)	1.39	agriculture/grassland	Young et al. 2009b
Howard, NY (2012)	10	Agriculture;Forest/Woodlot;Pasture	Tidhar et al. 2013c
Howard, NY (2013)	2.13	Agriculture;Forest/Woodlot;Pasture	Lukins et al. 2014
Judith Gap, MT (2006-2007)	8.93	agriculture/grassland	TRC Environmental Corporation 2008
Judith Gap, MT (2009)	3.2	agriculture/grassland	Poulton and Erickson 2010
Kewaunee County, WI (1999-2001)	6.45	agriculture	Howe et al. 2002
Kibby, ME (2011)	0.12	forest; commercial forest	Stantec 2012a
Kittitas Valley, WA (2011-2012)	0.12	sagebrush-steppe, grassland	Stantec Consulting Services 2012
Klondike II, OR (2005-2006)	0.41	agriculture/grassland	Northwest Wildlife Consultants (NWC) and WEST 2007
Klondike III (Phase I), OR (2007-2009)	1.11	agriculture/grassland	Gritski et al. 2010
Klondike IIIa (Phase II), OR (2008-2010)	0.14	grassland/shrub-steppe and agriculture	Gritski et al. 2011
Klondike, OR (2002-2003)	0.77	agriculture/grassland	Johnson et al. 2003
Lakefield Wind, MN (2012)	19.87	agriculture	Minnesota Public Utilities Commission 2012
Leaning Juniper, OR (2006-2008)	1.98	agriculture	Gritski et al. 2008
Lempster, NH (2009)	3.11	grasslands/forest/rocky embankments	Tidhar et al. 2010
Lempster, NH (2010)	3.57	grasslands/forest/rocky embankments	Tidhar et al. 2011
Linden Ranch, WA (2010-2011)	1.68	grassland/shrub-steppe, agriculture	Enz and Bay 2011
Locust Ridge, PA (Phase II; 2009)	14.11	grassland	Arnett et al. 2011
Locust Ridge, PA (Phase II; 2010)	14.38	grassland	Arnett et al. 2011
Lower West, CA (2012-2013)	2.17	Joshua Tree;Shrub Steppe	Levenstein and Bay 2013a
Lower West, CA (2014-2015)	1.13	Joshua Tree;Shrub Steppe	Levenstein and DiDonato 2015
Lower West, CA (2016-2017)	0	Joshua Tree;Shrub Steppe	WEST 2017b
Maple Ridge, NY (2006)	11.21	agriculture/forested	Jain et al. 2007

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Maple Ridge, NY (2007-2008)	6.49	agriculture/forested	Jain et al. 2009a
Maple Ridge, NY (2007)	4.96	agriculture/forested	Jain et al. 2009b
Maple Ridge, NY (2012)	7.3	agriculture/forested	Tidhar et al. 2013b
Marengo I, WA (2009-2010)	0.17	agriculture	URS 2010b
Marengo II, WA (2009-2010)	0.27	agriculture	URS 2010c
Mars Hill, ME (2007)	2.91	forest	Stantec 2008a
Mars Hill, ME (2008)	0.45	forest	Stantec 2009a
Milford I & II, UT (2011-2012)	1.67	desert shrub	Stantec 2011b
Milford I, UT (2010-2011)	2.05	desert shrub	Stantec 2012b
Montezuma I, CA (2011)	1.9	agriculture and grasslands	ICF International 2012
Montezuma I, CA (2012)	0.84	agriculture and grasslands	ICF International 2013
Montezuma II, CA (2012-2013)	0.91	agriculture	Harvey & Associates 2013
Moraine II, MN (2009)	2.42	agriculture/grassland	Derby et al. 2010f
Mount Storm, WV (2009)	17.53	forest	Young et al. 2009c
Mount Storm, WV (2010)	15.18	forest	Young et al. 2009a, 2010b
Mount Storm, WV (2011)	7.43	forest	Young et al. 2010a, 2011b
Mount Storm, WV (Fall 2008)	6.62	forest	Young et al. 2011a, 2012a
Mountaineer, WV (2003)	31.69	forest	Kerns and Kerlinger 2004
Munnsville, NY (2008)	1.93	agriculture/forest	Stantec 2009b
Mustang Hills, CA (2012-2013)	0.1	Grasslands and Riparian	Chatfield and Bay 2014
Mustang Hills, CA (2014-2015)	0	Desert Creosote;Grassland;Joshua Tree	WEST 2016c
Nine Canyon, WA (2002-2003)	2.47	agriculture/grassland	Erickson et al. 2003
Noble Altona, NY (2010)	4.34	forest	Jain et al. 2011a
Noble Bliss, NY (2008)	7.8	agriculture/forest	Jain et al. 2009c
Noble Bliss, NY (2009)	3.85	agriculture/forest	Jain et al. 2010c
Noble Chateaugay, NY (2010)	2.44	agriculture	Jain et al. 2011b
Noble Clinton, NY (2008)	3.14	agriculture/forest	Jain et al. 2009d
Noble Clinton, NY (2009)	4.5	agriculture/forest	Jain et al. 2010a
Noble Ellenburg, NY (2008)	3.46	agriculture/forest	Jain et al. 2009e
Noble Ellenburg, NY (2009)	3.91	agriculture/forest	Jain et al. 2010b
Noble Wethersfield, NY (2010)	16.3	agriculture	Jain et al. 2011c
NPPD Ainsworth, NE (2006)	1.16	agriculture/grassland	Derby et al. 2007
Pacific Wind, CA (2014-2015)	0.21	Desert Creosote;Joshua Tree;Pinyon Pine/ Juniper	WEST 2016a
Pacific Wind, CA (2015-2016)	0	Desert Creosote;Joshua Tree;Pinyon Pine/ Juniper	WEST 2017a
Palouse Wind, WA (2012-2013)	4.23	agriculture and grasslands	Stantec 2013a

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Pebble Springs, OR (2009-2010)	1.55	grassland	Gritski and Kronner 2010b
Pinnacle, WV (2012)	40.2	forest	Hein et al. 2013b
Pinyon Pines I & II, CA (2013-2014)	0.04	NA	Chatfield and Russo 2014
Pinyon Pines I & II, CA (2015-2016)	0.18	Desert Creosote;Joshua Tree	Rintz and Starcevich 2016
Pioneer Prairie I, IA (Phase II; 2011-2012)	4.43	agriculture, grassland	Chodachek et al. 2012
Pioneer Prairie II, IA (2013)	3.83	agriculture	Chodachek et al. 2014
Pleasant Valley, MN (2016-2017)	1.8	Agriculture;Grassland;Wetlands	Tetra Tech 2017b
Prairie Rose, MN (2014)	0.41	Agriculture;Grassland	Chodachek et al. 2015
PrairieWinds ND1 (Minot), ND (2010)	2.13	agriculture	Derby et al. 2011d
PrairieWinds ND1 (Minot), ND (2011)	1.39	agriculture, grassland	Derby et al. 2012d
PrairieWinds SD1, SD (2011-2012)	1.23	grassland	Derby et al. 2012c
PrairieWinds SD1, SD (2012-2013)	1.05	grassland	Derby et al. 2013a
PrairieWinds SD1, SD (2013-2014)	0.52	grassland	Derby et al. 2014
Prince Wind Farm, ON (2006)	1.27	forest	NRSI 2008
Prince Wind Farm, ON (2007)	1.03	forest	NRSI 2008
Prince Wind Farm, ON (2008)	2.39	forest	NRSI 2009
Rail Splitter, IL (2012-2013)	11.21	agriculture	Good et al. 2013b
Record Hill, ME (2012)	2.96	forest	Stantec 2013b
Record Hill, ME (2014)	0.55	forest	Stantec 2015a
Record Hill, ME (2016)	1.25	Forest/Woodlot;Rocky Outcrop	Stantec 2017
Red Hills, OK (2012-2013)	0.11	grassland	Derby et al. 2013c
Ripley, ON (2008)	4.67	agriculture	Jacques Whitford 2009
Rollins, ME (2012)	0.18	forest	Stantec 2013c
Rollins, ME (2014)	0.33	Forest/Woodlot;Gravel	Stantec 2015b
Roth Rock, MD (2011)	6.24	Forest/Woodlot;Rocky Outcrop	Atwell, LLC 2012
Rugby, ND (2010-2011)	1.6	agriculture	Derby et al. 2011c
Shiloh I, CA (2006-2009)	3.92	agriculture/grassland	Kerlinger et al. 2009
Shiloh II, CA (2009-2010)	2.6	agriculture	Kerlinger et al. 2010
Shiloh II, CA (2010-2011)	3.8	agriculture	Kerlinger et al. 2013a
Shiloh II, CA (2011-2012)	3.4	agriculture	Kerlinger et al. 2013a
Shiloh III, CA (2012-2013)	0.4	NA	Kerlinger et al. 2013b

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Solano III, CA (2012-2013)	0.31	NA	AECOM 2013
Spring Valley, NV (2012-2013)	3.73	Grassland;Shrub Steppe	WEST 2014
Spruce Mountain Wind Project, ME (2014)	0.31	Forest/Woodlot;Gravel;Rocky Outcrop	Tetra Tech 2015
Stateline, OR/WA (2001-2002)	1.09	agriculture/grassland	Erickson et al. 2004
Stateline, OR/WA (2003)	2.29	agriculture/grassland	Erickson et al. 2004
Stateline, OR/WA (2006)	0.95	agriculture/grassland	Erickson et al. 2007
Steel Winds I & II, NY (2013)	6.14	Deciduous Shrub;Grassland;Gravel;Other	Stantec 2014c
Stetson II, ME (2014)	0.83	Bermuda Grass/Mixed Grasses;Forest/Woodlot	Stantec 2015c
Stetson Mountain I, ME (2009)	1.4	forest	Stantec 2009c
Stetson Mountain I, ME (2011)	0.28	forest	Normandeau Associates 2011
Stetson Mountain I, ME (2013)	0.18	forest	Stantec 2014d
Stetson Mountain II, ME (2010)	1.65	forest	Normandeau Associates 2010
Stetson Mountain II, ME (2012)	2.27	forest	Stantec 2013d
Summerview, AB (2005-2006)	10.27	agriculture	Brown and Hamilton 2006
Summerview, AB (2006-2007)	11.42	agriculture/grassland	Baerwald 2008
Top Crop I & II (2012-2013)	12.55	agriculture	Good et al. 2013c
Top of Iowa, IA (2003)	7.16	agriculture	Jain 2005
Top of Iowa, IA (2004)	10.27	agriculture	Jain 2005
Top of the World, WY (2010-2011)	2.74	Grassland; Other	Rintz and Bay 2012
Top of the World, WY (2011-2012)	2.43	Grassland; Other	Rintz and Bay 2013
Top of the World, WY (2012-2013)	2.34	Grassland Other	Rintz and Bay 2014
Tucannon River, WA (2015)	2.22	Cropland; Developed; Grassland; Shrub Steppe; Winter Wheat	Hallingstad et al. 2016
Tuolumne (Windy Point I), WA (2009-2010)	0.94	grassland/shrub-steppe, agriculture and forest	Enz and Bay 2010
Vansycle, OR (1999)	1.12	agriculture/grassland	Erickson et al. 2000
Vantage, WA (2010-2011)	0.4	Shrub-steppe, grassland	Ventus Environmental Solutions 2012
Waverly Wind, KS (2016-2017)	8.2	Agriculture; Grassland	Tetra Tech 2017a
Wessington Springs, SD (2009)	1.48	grassland	Derby et al. 2010c
Wessington Springs, SD (2010)	0.41	grassland	Derby et al. 2011a

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
White Creek, WA (2007-2011)	2.04	grassland/shrub-steppe, agriculture	Downes and Gritski 2012b
Wild Horse, WA (2007)	0.39	grassland	Erickson et al. 2008
Windstar, CA (2012-2013)	0	Grassland; Pinyon Pine/ Juniper	Levenstein and Bay 2013b
Windy Flats, WA (2010-2011)	0.41	grassland/shrub-steppe, agriculture	Enz et al. 2011
Winnebago, IA (2009-2010)	4.54	agriculture/grassland	Derby et al. 2010a
Wolfe Island, ON (July-December 2009)	6.42	grassland	Stantec Consulting Ltd. (Stantec Ltd.) 2010
Wolfe Island, ON (July-December 2010)	9.5	grassland	Stantec Ltd. 2011
Wolfe Island, ON (July-December 2011)	2.49	grassland	Stantec Ltd. 2012

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Alite, CA (2009-2010)	8	24	80	8	200 m x 200 m	1 year	weekly (spring, fall), bi-monthly (summer, winter)
Alta I, CA (2013-2014)	290	720	80	NA	120 m radius	1 year	monthly; twice per month
Alta I, CA (2015-2016)	290	720	80	NA	120 m radius	1 year	monthly; twice per month
Alta II-V, CA (2013-2014)	290	720	80	NA	120 m radius	1 year	monthly; twice per month
Alta II-V, CA (2015-2016)	290	720	80	NA	120 m radius	1 year	monthly; twice per month
Alta VIII, CA (2012-2013)	50	150	90	12 plots (equivalent to 15 turbines)	240 x 240 m	1 year	bi-weekly
Alta VIII, CA (2014-2015)	100	300	90	NA	240 m x 240 m	NA	twice per month
Alta Wind I, CA (2011-2012)	100	150	80	25	120-m radius circle	12.5 months	every two weeks
Alta Wind II-V, CA (2011-2012)	190	570	80	41	120-m radius circle	14.5 months	every two weeks
Alta X, CA (2014-2015)	48	137	100	NA	240 m x 240 m	1 year	twice per month
Alta X, CA (2015-2016)	48	137	100	NA	240 m x 240 m	1 year	twice per month
Barton Chapel, TX (2009-2010)	60	120	78	30	200 m x 200 m	1 year	10 turbines weekly, 20 monthly
Barton I & II, IA (2010-2011)	80	160	100	35 (9 turbines were dropped in June 2010 due to landowner issues) 26 turbines were searched for the remainder of the study	200 m x 200 m	1 year	weekly (spring, fall; migratory turbines), monthly (summer, winter; non-migratory turbines)
Beech Ridge, WV (2012)	67	100.5	80	67	40 m radius	7 months	every two days
Beech Ridge, WV (2013)	67	100.5	80	67	40 m radius	7.5 months	every two days

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Big Blue, MN (2013)	18	36	78 or 90 (according to Gamesa website)	18	200m diameter	NA	weekly, monthly (Nov and Dec)
Big Blue, MN (2014)	18	36	78 or 90 (according to Gamesa website)	18	200m diameter	NA	weekly, monthly (Nov and Dec)
Big Horn, WA (2006-2007)	133	199.5	80	133	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Big Smile, OK (2012-2013)	66	132	78	17 (plus one met tower)	100 x 100	1 year	weekly (spring, summer, fall), monthly (winter)
Biglow Canyon, OR (Phase I; 2008)	76	125.4	80	50	110 m x 110 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Biglow Canyon, OR (Phase I; 2009)	76	125.4	80	50	110 m x 110 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Biglow Canyon, OR (Phase II; 2009-2010)	65	150	80	50	250 m x 250 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Biglow Canyon, OR (Phase II; 2010-2011)	65	150	80	50	252 m x 252 m	1 year	bi-weekly(spring, fall), monthly (summer, winter)
Biglow Canyon, OR (Phase III; 2010-2011)	76	174.8	80	50	252 m x 252 m	1 year	bi-weekly(spring, fall), monthly (summer, winter)
Bingham Wind Project, ME (2017)	56	185	94	NA	within 80m; within 140 m	7 months	twice per week
Blue Sky Green Field, WI (2008; 2009)	88	145	80	30	160 m x 160 m	fall, spring	daily(10 turbines), weekly (20 turbines)
Buffalo Gap I, TX (2006)	67	134	78	21	215 m x 215 m	10 months	every 3 weeks
Buffalo Gap II, TX (2007-2008)	155	233	80	36	215 m x 215 m	14 months	every 21 days
Buffalo Mountain, TN (2000-2003)	3	1.98	65	3	50-m radius	3 years	bi-weekly, weekly, bi-monthly
Buffalo Mountain, TN (2005)	18	28.98	V47 = 65; V80 = 78	18	50-m radius	1 year	bi-weekly, weekly, bi-monthly, and 2 to 5 day intervals

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Buffalo Ridge I, SD (2009-2010)	24	50.4	79	24	200 m x 200 m	1 year	weekly (migratory), monthly (non-migratory)
Buffalo Ridge II, SD (2011-2012)	105	210	78	65 (60 road and pad, 5 turbine plots)	100 x 100m	1 year	weekly (spring, summer, fall), monthly (winter)
Buffalo Ridge, MN (Phase I; 1999)	73	25	36	21	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase II; 1998)	143	107.25	50	40	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase II; 1999)	143	107.25	50	40	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	143	107.25	50	83	60 m x 60 m	summer, fall	bi-monthly
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	143	107.25	50	103	60 m x 60 m	summer, fall	bi-monthly
Buffalo Ridge, MN (Phase III; 1999)	138	103.5	50	30	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	138	103.5	50	83	60 m x 60 m	summer, fall	bi-monthly
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	138	103.5	50	103	60 m x 60 m	summer, fall	bi-monthly
Bull Hill, ME (2013)	19	34	95	19	80 m radius	6 months	weekly (spring), daily and weekly (fall)
Cameron Ridge/Section 15, CA (2014-2015)	34	102	80	NA	62.5m radius	1 year	weekly
Cameron Ridge/Section 15, CA (2015-2016)	34	102	80	NA	125m radius	NA	weekly
Casselman Curtailment, PA (2008)	23	35.4	80	12 experimental; 10 control	126 m x 120 m	2.5 months	daily
Casselman, PA (2008)	23	34.5	80	10	126 m x 120 m	7 months	daily
Casselman, PA (2009)	23	34.5	80	10	126 m x 120 m	7.5 months	daily searches

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Cedar Ridge, WI (2009)	41	67.6	80	20	160 m x 160 m	spring, summer, fall	daily, every 4 days; late fall searched every 3 days
Cedar Ridge, WI (2010)	41	68	80	20	160 m x 160 m	1 year	Five turbines were surveyed daily, 15 turbines surveyed every 4 days in rotating groups each day. All 20 surveyed every three days during late fall
Chopin, OR (2016-2017)	6	10	NA	NA	270m x 270m	1 year	monthly
Cohocton/Dutch Hill, NY (2009)	50	125	80	17	130 m x 130 m	spring, summer, fall	daily (5 turbines), weekly (12 turbines)
Cohocton/Dutch Hill, NY (2013)	50	125	80	NA	120m x 120m	4 months	weekly
Cohocton/Dutch Hills, NY (2010)	50	125	80	17	120 m x 120 m	spring, summer, fall	daily, weekly
Combine Hills, OR (2011)	104	104	53	52 (plus 1 MET tower)	180 m x 180 m	1 year	bi-weekly(spring, fall), monthly (summer, winter)
Combine Hills, OR (Phase I; 2004-2005)	41	41	53	41	90-m radius	1 year	monthly
Crescent Ridge, IL (2005-2006)	33	49.5	80	33	70-m radius	1 year	weekly (fall, spring)
Criterion, MD (2011)	28	70	80	28	40-50m radius	7.3 months	daily
Criterion, MD (2012)	28	70	80	14	40-50m radius	7.5 months	weekly
Criterion, MD (2013)	28	70	80	14	40-50m radius	7.5 months	weekly
Crystal Lake II, IA (2009)	80	200	80	16 turbines through week 6, and then 15 for duration of study	100 m x 100 m	spring, summer, fall	3 times per week for 26 weeks
Diablo Winds, CA (2005-2007)	31	20.46	50 and 55	31	75 m x 75 m	2 years	monthly
Dillon, CA (2008-2009)	45	45	69	15	200 m x 200 m	1 year	weekly, bi-monthly in winter

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Dry Lake I, AZ (2009-2010)	30	63	78	15	160 m x 160 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Dry Lake II, AZ (2011-2012)	31	65	78	31: 5 (full plot), 26 (road & pad)	160 m x 160 m	1 year	twice weekly (spring, summer, fall), weekly (winter)
Elkhorn, OR (2008)	61	101	80	61	220 m x 220 m	1 year	monthly
Elkhorn, OR (2010)	61	101	80	31	220 m x 220 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Elm Creek II, MN (2011-2012)	62	148.8	80	30	200 x 200m (2 random migration search areas 100 x 100m)	1 year	20 searched every 28 days, 10 turbines every 7 days during migration)
Elm Creek, MN (2009-2010)	67	100	80	29	200 m x 200 m	1 year	weekly, monthly
Foote Creek Rim I, WY (1999)	69	41.4	40	69	126 m x 126 m	1 year	monthly
Foote Creek Rim I, WY (2000)	69	41.4	40	69	126 m x 126 m	1 year	monthly
Foote Creek Rim I, WY (2001-2002)	69	41.4	40	69	126 m x 126 m	1 year	monthly
Forward Energy Center, WI (2008-2010)	86	129	80	29	160 m x 160 m	2 years	11 turbines daily, 9 every 3 days, 9 every 5 days
Fowler I, II, III, IN (2010)	355	600	Vestas = 80, Clipper = 80, GE = 80	36 turbines, 100 road and pads	80 m x 80 m for turbines ; 40-m radius for roads and pads	spring, fall	daily, weekly
Fowler I, II, III, IN (2011)	355	600	Vestas = 80, Clipper = 80, GE = 80	177 road and pads (spring), 9 turbines & 168 roads and pads (fall)	turbines (80 m circular plot), roads and pads (out to 80 m)	spring, fall	daily, weekly
Fowler I, II, III, IN (2012)	355	600	Vestas = 80, Clipper = 80, GE = 80	118 roads and pads	roads and pads (out to 80 m)	2.5 months	weekly

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Fowler I, IN (2009)	162	301	78 (Vestas), 80 (Clipper)	25	160 m x 160 m	spring, summer, fall	weekly, bi-weekly
Fowler III, IN (2009)	60	99	78	12	160 m x 160 m	10 weeks	weekly, bi-weekly
Fowler, IN (2014)	355	600	80	NA	road/pad; 80m radius	3 months	twice per week
Fowler, IN (2015)	355	600	80	NA	road/pad; 80m radius	3 months	twice per week
Fowler, IN (2016)	420	NA	80	NA	road/pad; 80m radius	3 months	weekly
Goodnoe, WA (2009-2010)	47	94	80	24	180 m x 180 m	1 year	14 days during migration periods, 28 days during non-migration periods
Grand Ridge I, IL (2009-2010)	66	99	80	30	160 m x 160 m	1 year	weekly, monthly
Groton, NH (2013)	24	48	78	NA	road/pad; 60m radius	7 months	weekly
Groton, NH (2014)	24	48	78	NA	road/pad; 60m radius	6 months	weekly
Groton, NH (2015)	24	48	78	NA	road/pad; 60m radius	6 months	weekly
Hancock, ME (2017)	17	51	80	NA	within 80 m; within 140 m	7 months	twice per week
Harrow, ON (2010)	24 (four 6-turb facilities)	39.6	NA	12 in July, 24 Aug-Oct	50-m radius from turbine base	4 months	twice-weekly
Harvest Wind, WA (2010-2012)	43	98.9	80	32	180 m x 180 m & 240 m x 240 m	2 years	twice a week, weekly and monthly
Hatchet Ridge, CA (2011)	44	101	80	NA	127m x 127m (bi-monthly), 190m x 190m (monthly)	NA	monthly;twice per month
Hatchet Ridge, CA (2012-2013)	44	NA	80	NA	127m x 127m	1 year	twice per month
Hatchet Ridge, CA (2012)	44	101	80	NA	127m x 127m (bi-monthly), 190m x 190m (monthly)	NA	monthly;twice per month

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Hay Canyon, OR (2009-2010)	48	100.8	79	20	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
High Sheldon, NY (2010)	75	112.5	80	25	115 m x 115 m	7 months	daily (8 turbines), weekly (17 turbines)
High Sheldon, NY (2011)	75	112.5	80	25	115 m x 115 m	7 months	daily (8 turbines), weekly (17 turbines)
High Winds, CA (2003-2004)	90	162	60	90	75-m radius	1 year	bi-monthly
High Winds, CA (2004-2005)	90	162	60	90	75-m radius	1 year	bi-monthly
Hopkins Ridge, WA (2006)	83	150	67	41	180 m x 180 m	1 year	monthly, weekly (subset of 22 turbines spring and fall migration)
Hopkins Ridge, WA (2008)	87	156.6	67	41-43	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Howard, NY (2012)	27	54	78.5	NA	120m x 120m	7 months	daily;weekly
Howard, NY (2013)	27	54	78.5	NA	120m x 120m	6 months	daily;weekly
Judith Gap, MT (2006-2007)	90	135	80	20	190 m x 190 m	7 months	monthly
Judith Gap, MT (2009)	90	135	80	30	100 m x 100 m	5 months	bi-monthly
Kewaunee County, WI (1999-2001)	31	20.46	65	31	60 m x 60 m	2 years	bi-weekly (spring, summer), daily (spring, fall migration), weekly (fall, winter)
Kibby, ME (2011)	44	132	124	22 turbines	75-m diameter circular plots	22 weeks	avg 5-day
Kittitas Valley, WA (2011-2012)	48	100.8	80	48	100 m x 102 m	1 year	bi-weekly from Aug 15 - Oct 31 and March 16 - May 15; every 4 weeks from Nov 1 - March 15 and May 16 - Aug 14
Klondike II, OR (2005-2006)	50	75	80	25	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (summer, winter)

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Klondike III (Phase I), OR (2007-2009)	125	223.6	GE = 80; Siemens= 80, Mitsubishi = 80	46	240 m x 240 m (1.5MW) 252 m x 252 m (2.3MW)	2 year	bi-monthly (spring, fall migration), monthly (summer, winter)
Klondike IIIa (Phase II), OR (2008-2010)	51	76.5	GE = 80	34	240 m x 240 m	2 years	bi-monthly (spring, fall), monthly (summer, winter)
Klondike, OR (2002-2003)	16	24	80	16	140 m x 140 m	1 year	monthly
Lakefield Wind, MN (2012)	137	205.5	80	26	100 m x 100 m	7.5 months	3 times per week
Leaning Juniper, OR (2006-2008)	67	100.5	80	17	240 m x 240 m	2 years	bi-monthly (spring, fall), monthly (winter, summer)
Lempster, NH (2009)	12	24	78	4	120 m x 130 m	6 months	daily
Lempster, NH (2010)	12	24	78	12	120 m x 130 m	6 months	weekly
Linden Ranch, WA (2010-2011)	25	50	80	25	110 m x 110 m	1 year	bi-weekly(spring, fall), monthly (summer, winter)
Locust Ridge, PA (Phase II; 2009)	51	102	80	15	120m x 126m	6.5 months	daily
Locust Ridge, PA (Phase II; 2010)	51	102	80	15	120m x 126m	6.5 months	daily
Lower West, CA (2012-2013)	7	14	110.5	NA	120m radius	NA	twice per month
Lower West, CA (2014-2015)	7	14	110.5	NA	120m radius	NA	twice per month
Lower West, CA (2016-2017)	7	14	110.5	NA	120m radius	1 year	twice per week
Maple Ridge, NY (2006)	120	198	80	50	130 m x 120 m	5 months	daily (10 turbines), every 3 days (10 turbines), weekly (30 turbines)
Maple Ridge, NY (2007-2008)	195	321.75	80	64	130 m x 120 m	7 months	weekly
Maple Ridge, NY (2007)	195	321.75	80	64	130 m x 120 m	7 months	weekly
Maple Ridge, NY (2012)	195	321.75	80	105 (5 turbines, 100 roads/pads)	100 m x 100 m	3 months	weekly

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Marengo I, WA (2009-2010)	78	140.4	67	39	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Marengo II, WA (2009-2010)	39	70.2	67	20	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Mars Hill, ME (2007)	28	42	80.5	28	76-m diameter, extended plot 238-m diameter	spring, summer, fall	daily (2 random turbines), weekly (all turbines): extended plot searched once per season
Mars Hill, ME (2008)	28	42	80.5	28	76-m diameter, extended plot 238-m diameter	spring, summer, fall	weekly: extended plot searched once per season
Milford I & II, UT (2011-2012)	107	160.5 (58.5 I, 102 II)	80	43	120x120	NA	every 10.5 days
Milford I, UT (2010-2011)	58	145	80	24	120x120	NA	weekly
Montezuma I, CA (2011)	16	36.8	80	16	105 m radius	1 year	Weekly and bi-Weekly
Montezuma I, CA (2012)	16	36.8	80	16	105 m radius	1 year	Weekly and bi-Weekly
Montezuma II, CA (2012-2013)	34	78.2	80	17	105 m radius	1 year	Weekly
Moraine II, MN (2009)	33	49.5	82.5	30	200 m x 200 m	1 year	weekly (migratory), monthly (non-migratory)
Mount Storm, WV (2009)	132	264	78	44	varied	4.5 months	weekly (28 turbines), daily (16 turbines)
Mount Storm, WV (2010)	132	264	78	24	20 to 60 m from turbine	6 months	daily
Mount Storm, WV (2011)	132	264	78	24	varied	6 months	daily
Mount Storm, WV (Fall 2008)	82	164	78	27	varied	3 months	weekly (18 turbines), daily (9 turbines)
Mountaineer, WV (2003)	44	66	80	44	60-m radius	7 months	weekly, monthly
Munnsville, NY (2008)	23	34.5	69.5	12	120 m x 120 m	spring, summer, fall	weekly

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Mustang Hills, CA (2012-2013)	50	150	90	13 plots (equivalent to 15 turbines)	240 x 240 m	1 year	bi-weekly
Mustang Hills, CA (2014-2015)	100	300	90	NA	240m x 240m	NA	twice per month
Mustang Hills, CA (2016-2017)	100	300	100	NA	240m x 240m	1 year	twice per month
Nine Canyon, WA (2002-2003)	37	48.1	60	37	90-m radius	1 year	bi-monthly (spring, summer, fall), monthly (winter)
Noble Altona, NY (2010)	65	97.5	80	22	120 m x 120 m	spring, summer, fall	daily, weekly
Noble Bliss, NY (2008)	67	100	80	23	120 m x 120 m	spring, summer, fall	daily (8 turbines), 3-day (8 turbines), weekly (7 turbines)
Noble Bliss, NY (2009)	67	100	80	23	120 m x 120 m	spring, summer, fall	weekly, 8 turbines searched daily from July 1 to August 15
Noble Chateaugay, NY (2010)	71	106.5	80	24	120 m x 120 m	spring, summer, fall	weekly
Noble Clinton, NY (2008)	67	100	80	23	120 m x 120 m	spring, summer, fall	daily (8 turbines), 3-day (8 turbines), weekly (7 turbines)
Noble Clinton, NY (2009)	67	100	80	23	120 m x 120 m	spring, summer, fall	daily (8 turbines), weekly (15 turbines), all turbines weekly from July 1 to August 15
Noble Ellenburg, NY (2008)	54	80	80	18	120 m x 120 m	spring, summer, fall	daily (6 turbines), 3-day (6 turbines), weekly (6 turbines)
Noble Ellenburg, NY (2009)	54	80	80	18	120 m x 120 m	spring, summer, fall	daily (6 turbines), weekly (12 turbines), all turbines weekly from July 1 to August 15
Noble Wethersfield, NY (2010)	84	126	80	28	120 m x 120 m	spring, summer, fall	weekly

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
NPPD Ainsworth, NE (2006)	36	20.5	70	36	220 m x 220 m	spring, summer, fall	bi-monthly
Oakfield, ME (2017)	48	148	94	NA	within 80 m; within 140 m	7 months	other
Odell, MN (2016-2017)	100	200	NA	NA	120m x 120m	1 year	monthly;weekly
Pacific Wind, CA (2014-2015)	70	144	78.5	NA	126m radius	NA	weekly
Pacific Wind, CA (2015-2016)	70	144	78.5	NA	63m radius	NA	weekly
Palouse Wind, WA (2012-2013)	58	104.4	80, 90, or 105 M (according to the Vestas website)	19	120m x 120m	1 year	Montly (Winter) and Weekly (Spring-Fall)
Pebble Springs, OR (2009-2010)	47	98.7	79	20	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Pinnacle, WV (2012)	23	55.2	80	11	126 m x 120m	9 months	weekly
Pinyon Pines I & II, CA (2013-2014)	100	NA	90	25 plots (aprox 31 turbines)	240x240 m	NA	bi-weekly
Pinyon Pines I & II, CA (2015-2016)	100	300	90	NA	240m x 240m	NA	twice per month
Pioneer Prairie I, IA (Phase II; 2011-2012)	62	102.3	80	62 (57 road/pad) 5 full search plots	80 x 80m	1 year	weekly (spring and fall), every two weeks (summer), monthly (winter)
Pioneer Prairie II, IA (2013)	62	102.3	80	62	80x80 m (5 turbines), road and pad within 100 m of turbine (57 turbines)	NA	weekly
Pleasant Valley, MN (2016-2017)	100	200	95	NA	160m x 160m	NA	weekly
Prairie Rose, MN (2014)	119	200	80	NA	100m x 100m (spring); road/pad (fall)	1 year	weekly

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
PrairieWinds ND1 (Minot), ND (2010)	80	115.5	89	35	minimum of 100 m x 100 m	3 seasons	bi-monthly
PrairieWinds ND1 (Minot), ND (2011)	80	115.5	80	35	minimum 100 x 100m	3 season	twice monthly
PrairieWinds SD1, SD (2011-2012)	108	162	80	50	200 x 200m	1 year	twice monthly (spring, summer, fall), monthly (winter)
PrairieWinds SD1, SD (2012-2013)	108	162	80	50	200 x 200m	1 year	bi-weekly
PrairieWinds SD1, SD (2013-2014)	108	162	80	45	200 x 200m	1 year	twice monthly (spring, summer, fall), monthly (winter)
Prince Wind Farm, ON (2006)	126	189	80	38	63-m radius	4 months	daily, weekly
Prince Wind Farm, ON (2007)	126	189	80	38 turbines from January 1st - July 8th, 126 turbines from July 9th-October 31st	63- to 45-m radius	10 months	daily, weekly
Prince Wind Farm, ON (2008)	126	189	80	126	45m radius	6.5 months	daily, 3x/week, 2x/week
Rail Splitter, IL (2012-2013)	67	100.5	80	34	60 m radius	1 year	weekly (spring, summer, and fall) and bi-weekly (winter)
Record Hill, ME (2012)	22	50.6	80	22	126.5x126.5	5 months	three times every two weeks
Record Hill, ME (2014)	22	50.6	80	10	varied due to steep terrain and heavily vegetated areas	4.5 months	daily for 5 days a week
Record Hill, ME (2016)	22	51	80	NA	42.5m radius	7 months	other
Red Hills, OK (2012-2013)	82	123	80	20 (plus one met tower)	100 x 100	1 year	weekly (spring, summer, fall), monthly (winter)
Ripley, ON (2008)	38	76	64	38	80 m x 80 m	spring, fall	twice weekly for odd turbines; weekly for even turbines.

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Rollins, ME (2012)	40	60	80	20	varied; turbine laydown area and gravel access roads out to 60m	6 months	weekly
Rollins, ME (2014)	40	60	NA	NA	60m radius	6 months	weekly
Roth Rock, MD (2011)	20	50	80	NA	80m x 80m	3 months	daily
Rugby, ND (2010-2011)	71	149	78	32	200 m x 200 m	1 year	weekly (spring, fall; migratory turbines), monthly (non-migratory turbines)
Shiloh I, CA (2006-2009)	100	150	65	100	105-m radius	3 years	weekly
Shiloh II, CA (2009-2010)	75	150	80	25	100m radius	1 year	weekly
Shiloh II, CA (2010-2011)	75	150	80	25	100 m radius	1 year	weekly
Shiloh II, CA (2011-2012)	75	150	80	25	100 m radius	1 year	weekly
Shiloh III, CA (2012-2013)	50	102.5	78.5	25	100 m radius	NA	weekly
Solano III, CA (2012-2013)	55	128	80	19	100 m radius	NA	bi-Weekly
Spring Valley, NV (2012-2013)	66	152	80	NA	126m x 126m	1 year, 2 months	daily;twice per month
Spruce Mountain Wind Project, ME (2014)	10	20	78	NA	road/pad; 100m radius	NA	twice per week
Stateline, OR/WA (2001-2002)	454	299	50	124	minimum 126 m x 126 m	17 months	bi-weekly, monthly
Stateline, OR/WA (2003)	454	299	50	153	minimum 126 m x 126 m	1 year	bi-weekly, monthly
Stateline, OR/WA (2006)	454	299	50	39	variable turbine strings	1 year	bi-weekly
Steel Winds I & II, NY (2013)	14	35	80	NA	120m x 120m	5 months	twice per week
Stetson II, ME (2014)	17	26	NA	NA	60m radius	6 months	weekly

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Stetson Mountain I, ME (2009)	38	57	80	19	76-m diameter	27 weeks (spring, summer, fall)	weekly
Stetson Mountain I, ME (2011)	38	57	80	19	79.45x79.45m	6 months	weekly
Stetson Mountain I, ME (2013)	38	57	80	19	76 m diameter	6 months	weekly
Stetson Mountain II, ME (2010)	17	25.5	80	17	74.5x74.5m	6 months	weekly (3 turbines twice a week)
Stetson Mountain II, ME (2012)	17	25.5	80	17	laydown area and road up to 60m	6 months	weekly
Summerview, AB (2005-2006)	39	70.2	67	39	140 m x 140 m	1 year	weekly, bi-weekly (May to July, September)
Summerview, AB (2006-2007)	39	70.2	65	39	52-m radius; 2 spiral transects 7 m apart	summer, fall (2 years)	daily (10 turbines), weekly (29 turbines)
Top Crop I & II (2012-2013)	68 (phase I) 132 (phase (II)	300 (102 (phase I) 198 (phase II))	65 (phase I) 80 (phase II)	100	61 m radius	1 year	weekly (spring, summer, and fall) and bi-weekly (winter)
Top of Iowa, IA (2003)	89	80	71.6	26	76 m x 76 m	spring, summer, fall	once every 2 to 3 days
Top of Iowa, IA (2004)	89	80	71.6	26	76 m x 76 m	spring, summer, fall	once every 2 to 3 days
Top of the World, WY (2010-2011)	110	200	80	NA	160m x 160m	1 year	twice per month;weekly
Top of the World, WY (2011-2012)	110	200	80	NA	160m x 160m	1 year	twice per month;weekly
Top of the World, WY (2012-2013)	110	200	80	NA	160m x 160m	1 year	twice per month;weekly
Tucannon River, WA (2015)	116	267	80	NA	134m radius	1 year	

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Tuolumne (Windy Point I), WA (2009-2010)	62	136.6	80	21	180 m x 180 m	1 year	monthly throughout the year, a sub-set of 10 turbines were also searched weekly during the spring, summer, and fall
Vansycle, OR (1999)	38	24.9	50	38	126 m x 126 m	1 year	monthly
Vantage, WA (2010-2011)	60	90	80	30	240 m x 240 m	1 year	monthly, a subset of 10 searched weekly during migration
Waverly Wind, KS (2016-2017)	95	199	93	NA	160m x 160m; road/pad	1 year	twice per month;weekly
Wessington Springs, SD (2009)	34	51	80	20	200 m x 200 m	spring, summer, fall	bi-monthly
Wessington Springs, SD (2010)	34	51	80	20	200 m x 200 m	8 months	bi-weekly (spring, summer, fall)
White Creek, WA (2007-2011)	89	204.7	80	89	180 m x 180 m & 240 m x 240 m	4 years	twice a week, weekly and monthly
Wild Horse, WA (2007)	127	229	67	64	110 m from two turbines in plot	1 year	monthly, weekly (fall, spring migration at 16 turbines)
Windstar, CA (2012-2013)	53	106	107;110.5	NA	120m radius	NA	monthly;twice per month
Windy Flats, WA (2010-2011)	114	262.2	80	36 (plus 1 MET tower)	180 m x 180 m (120m at MET tower)	1 year	monthly (spring, summer, fall, and winter), weekly (spring and fall migration)
Winnebago, IA (2009-2010)	10	20	78	10	200 m x 200 m	1 year	weekly (migratory), monthly (non-migratory)
Wolfe Island, ON (July-December 2009)	86	197.8	80	86	60-m radius	summer, fall	43 twice weekly, 43 weekly
Wolfe Island, ON (July-December 2010)	86	197.8	80	86	50-m radius	6 months	43 twice weekly, 43 weekly
Wolfe Island, ON (July-December 2011)	86	197.8	80	86	50m radius	6 months	43 twice weekly, 43 weekly

Appendix A3 (*continued*). All post-construction monitoring studies, project characteristics, and select study methodology.

Data from the following sources:

Project, Location	Reference	Project, Location	Reference
Alite, CA	Chatfield et al. 2010	Klondike II, OR	NWC and WEST 2007
Alta Wind I, CA (11)	Chatfield et al. 2012	Klondike III (Phase I), OR	Gritski et al. 2010
Alta Wind II-V, CA (11)	Chatfield et al. 2012	Klondike IIIa (Phase II), OR	Gritski et al. 2011
Barton I&II, IA	Derby et al. 2011a	Leaning Juniper, OR	Gritski et al. 2008
Barton Chapel, TX	WEST 2011	Lempster, NH (09)	Tidhar et al. 2010
Beech Ridge, WV	Tidhar et al. 2013	Lempster, NH (10)	Tidhar et al. 2011
Big Horn, WA	Kronner et al. 2008	Linden Ranch, WA	Enz and Bay 2011
Big Smile, OK	Derby et al. 2013a	Locust Ridge, PA (Phase II; 09)	Arnett et al. 2011
Biglow Canyon, OR (Phase I; 08)	Jeffrey et al. 2009a	Locust Ridge, PA (Phase II; 10)	Arnett et al. 2011
Biglow Canyon, OR (Phase I; 09)	Enk et al. 2010	Madison, NY	Kerlinger 2002b
Biglow Canyon, OR (Phase II; 09/10)	Enk et al. 2011a	Maple Ridge, NY (06)	Jain et al. 2007
Biglow Canyon, OR (Phase II; 10/11)	Enk et al. 2012b	Maple Ridge, NY (07)	Jain et al. 2009a
Biglow Canyon, OR (Phase III; 10/11)	Enk et al. 2012a	Maple Ridge, NY (08)	Jain et al. 2009d
Blue Sky Green Field, WI	Gruver et al. 2009	Marengo I, WA (09)	URS Corporation 2010b
Buena Vista, CA	Insignia Environmental 2009	Marengo II, WA (09)	URS Corporation 2010c
Buffalo Gap I, TX	Tierney 2007	Mars Hill, ME (07)	Stantec 2008
Buffalo Gap II, TX	Tierney 2009	Mars Hill, ME (08)	Stantec 2009a
Buffalo Mountain, TN (00-03)	Nicholson et al. 2005	McBride, Alb (04)	Brown and Hamilton 2004
Buffalo Mountain, TN (05)	Fiedler et al. 2007	Melancthon, Ont (Phase I)	Stantec Ltd. 2008
Buffalo Ridge, MN (94/95)	Osborn et al. 1996, 2000	Meyersdale, PA (04)	Arnett et al. 2005
Buffalo Ridge, MN (Phase I; 96)	Johnson et al. 2000	Moraine II, MN	Derby et al. 2010d
Buffalo Ridge, MN (Phase I; 97)	Johnson et al. 2000	Mount Storm, WV (Fall 08)	Young et al. 2009b
Buffalo Ridge, MN (Phase I; 98)	Johnson et al. 2000	Mount Storm, WV (09)	Young et al. 2009a, 2010b
Buffalo Ridge, MN (Phase I; 99)	Johnson et al. 2000	Mount Storm, WV (10)	Young et al. 2010a, 2011b
Buffalo Ridge, MN (Phase II;98)	Johnson et al. 2000	Mount Storm, WV (11)	Young et al. 2011a, 2012b
Buffalo Ridge, MN (Phase II; 99)	Johnson et al. 2000	Mountaineer, WV (03)	Kerns and Kerlinger 2004
Buffalo Ridge, MN (Phase II; 01/Lake Benton I)	Johnson et al. 2004	Mountaineer, WV (04)	Arnett et al. 2005
Buffalo Ridge, MN (Phase II; 02/Lake Benton I)	Johnson et al. 2004	Munnsville, NY (08)	Stantec 2009b
Buffalo Ridge, MN (Phase III; 99)	Johnson et al. 2000	Nine Canyon, WA	Erickson et al. 2003
Buffalo Ridge, MN (Phase III; 01/Lake Benton II)	Johnson et al. 2004	Noble Altona, NY	Jain et al. 2011b
Buffalo Ridge, MN (Phase III; 02/Lake Benton II)	Johnson et al. 2004	Noble Bliss, NY (08)	Jain et al.2009e
Buffalo Ridge I, SD (10)	Derby et al. 2010b	Noble Bliss, NY (09)	Jain et al. 2010a
Buffalo Ridge II, SD (11)	Derby et al. 2012a	Noble Chateaugay, NY	Jain et al. 2011c
Casselman, PA (08)	Arnett et al. 2009a	Noble Clinton, NY (08)	Jain et al. 2009c
Casselman, PA (09)	Arnett et al. 2010	Noble Clinton, NY (09)	Jain et al. 2010b
Casselman Curtailment, PA (08)	Arnett et al. 2009b	Noble Ellenburg, NY (08)	Jain et al. 2009b
Castle River, Alb (01)	Brown and Hamilton 2006a	Noble Ellenburg, NY (09)	Jain et al. 2010c
Castle River, Alb (02)	Brown and Hamilton 2006a	Noble Wethersfield, NY	Jain et al. 2011a
Cedar Ridge, WI (09)	BHE Environmental 2010	NPPD Ainsworth, NE	Derby et al. 2007
Cedar Ridge, WI (10)	BHE Environmental 2011	Oklahoma Wind Energy Center, OK	Piorkowski and O'Connell 2010
Cohocton/Dutch Hill, NY (09)	Stantec 2010	Pebble Springs, OR	Gritski and Kronner 2010b
Cohocton/Dutch Hills, NY (10)	Stantec 2011	Pine Tree, CA	BioResource Consultants 2010
Combine Hills, OR	Young et al. 2006	Pioneer Prairie I, IA (Phase II)	Chodachek et al. 2012
Combine Hills, OR (11)	Enz et al. 2012	PrairieWinds ND1 (Minot), ND	Derby et al. 2011c
Condon, OR	Fishman Ecological Services 2003	PrairieWinds ND1 (Minot), ND (11)	Derby et al. 2012c
Crescent Ridge, IL	Kerlinger et al. 2007	PrairieWinds SD1, SD	Derby et al. 2012d
Criterion, MD (11)	Young et al. 2012a	Prince Wind Farm, Ont (06)	Natural Resource Solutions 2009
Criterion, MD (12)	Young et al. 2013	Prince Wind Farm, Ont (07)	Natural Resource Solutions 2009
Crystal Lake II, IA	Derby et al. 2010a	Prince Wind Farm, Ont (08)	Natural Resource Solutions 2009
Diablo Winds, CA	WEST 2006, 2008	Red Canyon, TX	Miller 2008
Dillon, CA	Chatfield et al. 2009	Red Hills, OK	Derby et al. 2013b
Dry Lake I, AZ	Thompson et al. 2011	Ripley, Ont (08)	Jacques Whitford 2009
Dry Lake II, AZ	Thompson and Bay 2012	Ripley, Ont (Fall 09)	Golder Associates 2010
Elkhorn, OR (08)	Jeffrey et a. 2009b	Rugby, ND	Derby et al. 2011b
Elkhorn, OR (10)	Enk et al. 2011b	San Gorgonio, CA	Anderson et al. 2005
Elm Creek, MN	Derby et al. 2010c	Searsburg, VT (07)	Kerlinger 2002a
Elm Creek II, MN	Derby et al. 2012b	Shiloh I, CA	Kerlinger et al. 2009
Erie Shores, Ont	James 2008	Shiloh II, CA	Kerlinger et al. 2010
Foote Creek Rim, WY (Phase I; 99)	Young et al. 2003a	SMUD Solano, CA	Erickson and Sharp 2005
Foote Creek Rim, WY (Phase I; 00)	Young et al. 2003a	Stateline, OR/WA (02)	Erickson et al. 2004
Foote Creek Rim, WY (Phase I; 01-02)	Young et al. 2003a	Stateline, OR/WA (03)	Erickson et al. 2004
Forward Energy Center, WI	Grodsky and Drake 2011	Stateline, OR/WA (06)	Erickson et al. 2007
Fowler I, IN (09)	Good et al. 2011	Stetson Mountain I, ME (09)	Stantec 2009c
Fowler I, II, III, IN (10)	Good et al. 2011	Stetson Mountain I, ME (11)	Normandeau Associates 2011
Fowler I, II, III, IN (11)	Good et al. 2012	Stetson Mountain II, ME (10)	Normandeau Associates 2010
Fowler I, II, III, IN (12)	Good et al. 2013	Summerview, Alb (06)	Brown and Hamilton 2006b
Fowler III, IN (09)	Good et al. 2011	Summerview, Alb (08)	Baerwald 2008
Goodnoe, WA	URS Corporation 2010a	Tehachapi, CA	Anderson et al. 2004

Appendix A3 (*continued*). All post-construction monitoring studies, project characteristics, and select study methodology.

Data from the following sources:

Project, Location	Reference	Project, Location	Reference
Grand Ridge I, IL	Derby et al. 2010g	Top of Iowa, IA (03)	Jain 2005
Harrow, Ont (10)	Natural Resource Solutions 2011	Top of Iowa, IA (04)	Jain 2005
Harvest Wind, WA (10-12)	Downes and Gritski 2012a	Tuolumne (Windy Point I), WA	Enz and Bay 2010
Hay Canyon, OR	Gritski and Kronner 2010a	Vansycle, OR	Erickson et al. 2000
High Sheldon, NY (10)	Tidhar et al. 2012a	Vantage, WA	Ventus Environmental Solutions 2012
High Sheldon, NY (11)	Tidhar et al. 2012b	Wessington Springs, SD (09)	Derby et al. 2010f
High Winds, CA (04)	Kerlinger et al. 2006	Wessington Springs, SD (10)	Derby et al. 2011d
High Winds, CA (05)	Kerlinger et al. 2006	White Creek, WA (07-11)	Downes and Gritski 2012b
Hopkins Ridge, WA (06)	Young et al. 2007	Wild Horse, WA	Erickson et al. 2008
Hopkins Ridge, WA (08)	Young et al. 2009c	Windy Flats, WA	Enz et al. 2011
Jersey Atlantic, NJ	NJAS 2008a, 2008b, 2009	Winnebago, IA	Derby et al. 2010e
Judith Gap, MT (06-07)	TRC 2008	Wolfe Island, Ont (May-June 09)	Stantec Ltd. 2010a
Judith Gap, MT (09)	Poulton and Erickson 2010	Wolfe Island, Ont (July-Dec 09)	Stantec Ltd. 2010b
Kewaunee County, WI	Howe et al. 2002	Wolfe Island, Ont (Jan-June 10)	Stantec Ltd. 2011a
Kibby, ME (11)	Stantec 2012	Wolfe Island, Ont (July-Dec 10)	Stantec Ltd. 2011b
Kittitas Valley, WA (11-12)	Stantec Consulting 2012	Wolfe Island, Ont (Jan-June 11)	Stantec Ltd. 2011c
Klondike, OR	Johnson et al. 2003	Wolfe Island, Ont (July-Dec 11)	Stantec Ltd. 2012

Bat Acoustic Activity Studies 2018

Bat Acoustic Activity Studies for the Three Waters Wind Farm Jackson County, Minnesota, and Osceola and Dickinson Counties, Iowa

Final Report

April 23 – October 15, 2018

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2019

EXECUTIVE SUMMARY

In April 2018, Western EcoSystems Technology, Inc. initiated a bat acoustic survey for the proposed Three Waters Wind Farm (Project) in Jackson County, Minnesota, and Osceola and Dickinson counties, Iowa. The bat acoustic survey conducted at the Project was designed to estimate levels of bat activity throughout the Project during the spring, summer, and fall.

Acoustic surveys were conducted from April 23 to October 15, 2018, using four AnaBat® SD2 (AnaBat) detectors. Two detectors were paired at a meteorological (met) tower in cultivated cropland representative of future turbine placement, with one microphone placed near the ground at 1.5 meters (m; 5.0 feet [ft]) and the other placed within the rotor-swept zone at 45 m (148 ft). The two remaining detectors were moved between four locations of temporary stations located near the ground in representative habitat as well as habitat potentially attractive to bats (e.g., deciduous forest, wetlands).

Overall, the AnaBat units recorded 7,473 bat passes on 670 detector-nights for a mean (± standard error) of 14.61 ± 1.39 bat passes per detector-night. Activity was nearly identical between the ground (1.64 bat passes per detector-night) and the raised (1.39 bat passes per detector-night) microphones at the met tower. Activity at temporary stations was more variable, ranging between 7.07 bat passes per detector-night and 36.57 bat passes per detector-night. Approximately 83% of bat passes were classified as low-frequency (e.g., big brown bats, hoary bats, and silver-haired bats), and 17% of bat passes were classified as high-frequency (e.g., eastern red bats and *Myotis* species). Hoary bats, eastern red bats, and silver-haired bats are the main casualties at other North American wind energy facilities, and it is expected these species will be the main bats killed at the Project. Bat activity was highest during the fall, peaking at fixed stations from August 20 to 26 (4.50 bat passes per detector-night). This timing of high bat activity corresponds with the period of peak bat fatality at most wind-energy facilities, and suggests most bat fatalities at the Project will occur during the late summer or early fall. Overall bat activity levels and timing of activity were similar to results from the 2017 bat surveys at the Project.

The bat pass rate for the fixed ground detector during the standardized Fall Migratory Period was 2.03 bat passes per detector-night. This activity rate was lower than the national median (7.68 bat passes per detector-night), and lower than most of the public studies from Midwest regions that have measured preconstruction bat activity and post-construction bat fatality. Mean activity was also lower than bat pass rates reported at the nearby Lakeview Wind Project in 2011 and in 2012. Post-construction monitoring of Lakefield in 2012 and in 2014 found estimated bat fatality rates of 19.87 and 20.19 bats/megawatt (MW), respectively. Hoary bat, eastern red bat, and silver-haired bat were the main species killed, and most bat fatalities occurred between mid-July and mid-September. Given the proximity of Lakefield to the Project, it is expected the Project will experience similar patterns in bat fatality, and the bat fatality rate will likely be less than 20 bats/MW/year.

STUDY PARTICIPANTS

Tim Sichmeller	Project Manager
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REPORT REFERENCE

Sichmeller, T. and D. Solick. 2019. Bat Acoustic Activity Studies for the Three Waters Wind Farm, Jackson County, Minnesota, and Osceola and Dickinson counties, Iowa. Final Report: April 23 – October 15, 2018. Prepared for Three Waters Wind Farm, LLC, Boulder, Colorado. Prepared by Western EcoSystems Technology, Inc. (WEST), Houston, Texas. 2019

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INTRODUCTION

Three Waters Wind Farm, LLC (Three Waters) contracted Western EcoSystems Technology, Inc., (WEST) to conduct surveys and monitor wildlife resources for the potential Three Waters Wind Farm (Project) in southwestern Minnesota and northwestern Iowa (Figure 1) to estimate the potential impacts of wind energy facility construction and operations on wildlife. This document provides results of the second year of studies of bat activity following the recommendations of the U.S. Fish and Wildlife Service (USFWS) Land-based Wind Energy Guidelines (WEG; USFWS 2012), Kunz et al. (2007a), and following the Minnesota Department of Natural Resources (MN-DNR) Avian and Bat Survey Protocols for Large Wind Energy Conversion Systems in Minnesota (Mixon et al. 2014). WEST conducted acoustic monitoring surveys to estimate levels of bat activity throughout the Project during the spring, summer, and fall. The following report describes the results of acoustic monitoring surveys conducted at the Project between April 23 and October 15, 2018.

STUDY AREA

The proposed Project is located at the Minnesota-Iowa border in Jackson County, Minnesota, and Osceola and Dickinson counties, Iowa, between the towns of Jackson and Worthington (Figure 1). The Project area encompasses approximately 23,843.1 hectares (58,917.6 acres; Figure 2). The Project area is within the Des Moines Lobe Level IV Ecoregion and the Western Corn Belt Plains Level III Ecoregion. The Western Corn Belt Plains is over 75% cultivated cropland and much of the remainder is forage for livestock. Most of the Des Moines Lobe has been converted from wet prairie to agricultural land. The Project area includes portions of the Little Sioux River and the West Fork of the Little Sioux River, along with other small drainages (Figure 2). The Project area also overlaps with several small lakes and ponds, including Illinois Lake, Skunk Lake, Rush Lake, and Iowa Lake (Figure 2). Based on the National Land Cover Database (NLCD; US Geological Survey NLCD 2011, Homer et al. 2015), land cover within the Project area is primarily (89.8%) cultivated cropland, with small portions of emergent herbaceous wetlands (3.2%); developed open space (3.1%); herbaceous (1.4%); open water (0.7%); hay pasture (0.5%), and other habitat types (Figure 2, Table 1).

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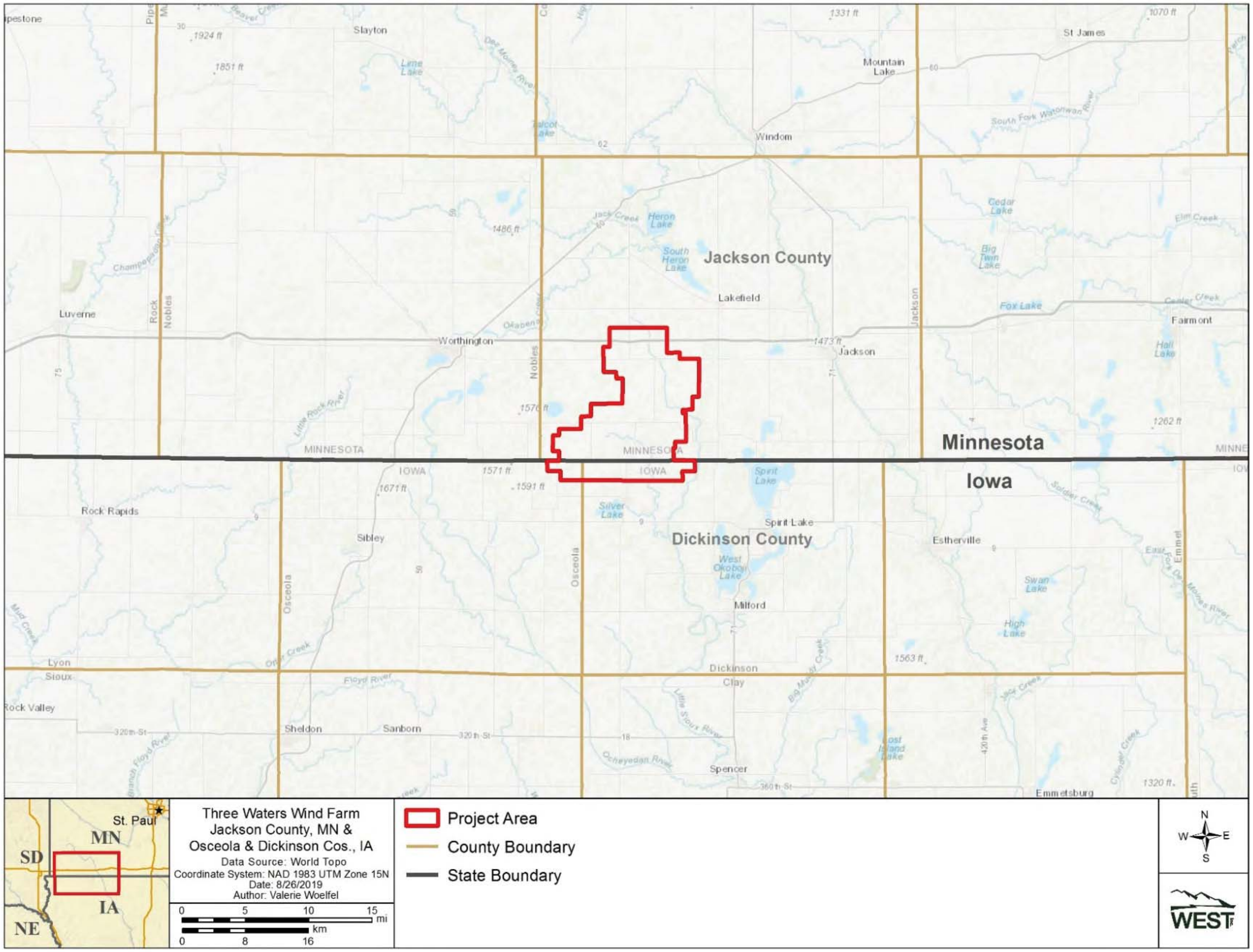

Figure 1. Topographic map showing the location of the Three Waters Wind Farm, Jackson County, Minnesota, and Osceola and Dickinson counties, Iowa.

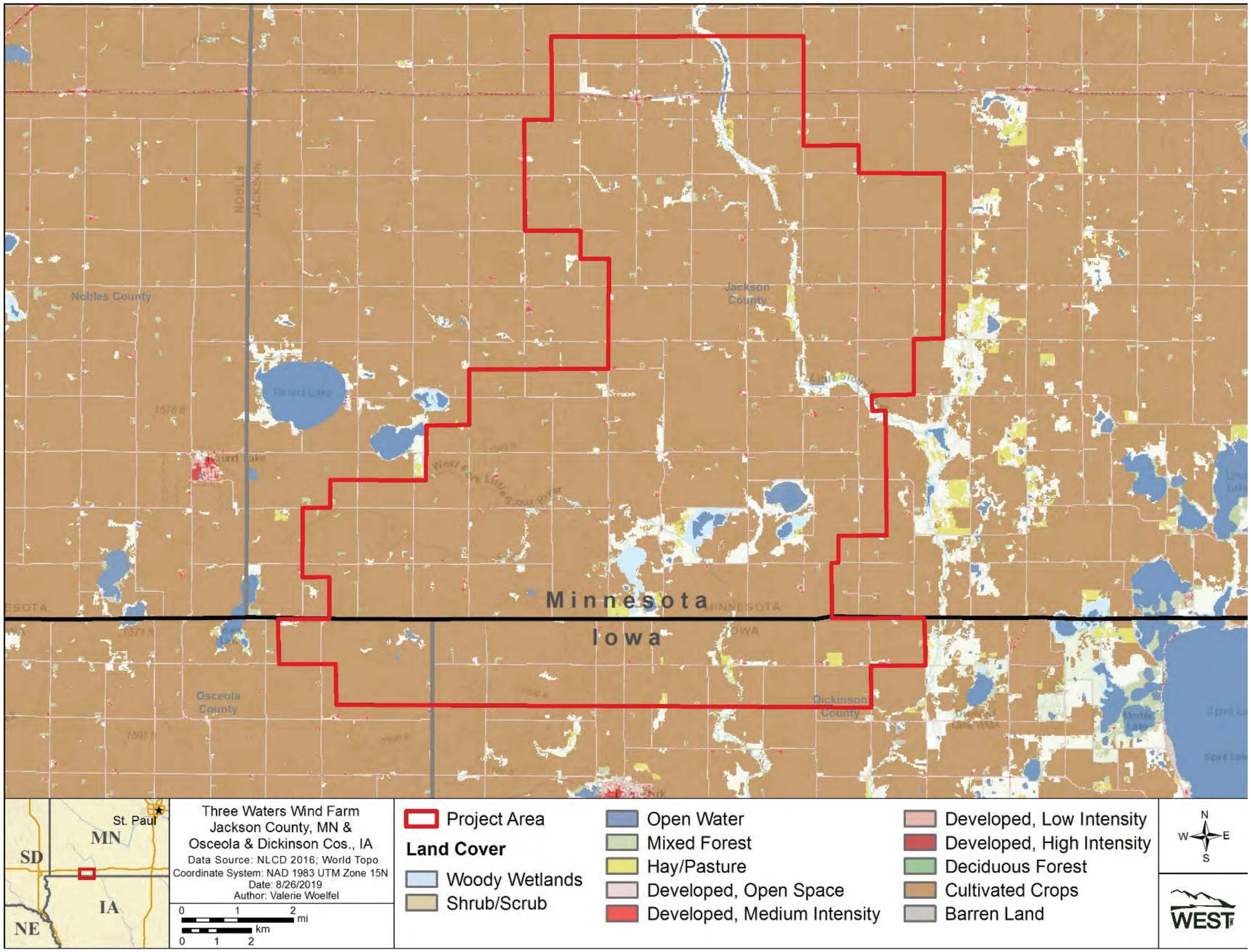

Figure 2. Land cover in the Three Waters Wind Farm, Jackson County, Minnesota, and Osceola and Dickinson counties Iowa (Yang et al. 2018, Multi-Resolution Land Characteristics 2019).

Table 1. Land cover types, coverage, and composition within the Three Waters Wind Farm in Jackson County, Minnesota, and Osceola and Dickinson counties Iowa.

Habitat	Hectares	Acres	% Composition
Cultivated Crops	21,419.0	52,927.5	89.8
Emergent Herbaceous Wetlands	764.2	1,888.3	3.2
Developed, Open Space	739.7	1,827.9	3.1
Herbaceous	335.7	829.5	1.4
Open Water	160.8	397.2	0.7
Hay/Pasture	128.6	317.7	0.5
Developed, Low Intensity	119.8	296.0	0.5
Mixed Forest	107.2	264.8	0.4
Developed, Medium Intensity	33.9	83.9	0.1
Deciduous Forest	10.4	25.6	<0.1
Shrub/Scrub	9.5	23.6	<0.1
Barren Land	6.1	15.1	<0.1
Woody Wetlands	5.6	13.8	<0.1
Developed, High Intensity	2.7	6.7	<0.1
Total[1]	**23,843.1**	**58,917.6**	**100**

Data from the National Land Cover Database (Yang et al. 2018, Multi-Resolution Land Characteristics 2019).

[1] Sums of values may not add to total value shown due to rounding.

Overview of Bat Diversity

There are seven species of bats are found in Minnesota (Table 2). Those species include: the big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), little brown bat (*M. lucifugus*), NLEB, and tri-colored bat (*Perimyotis subflavus*) all of which have been found as fatalities at wind energy facilities (Table 2). Of the seven species with the potential to occur in Minnesota, one (NLEB) is federally listed as threatened under the Endangered Species Act [ESA].

Table 2. Bat species with potential to occur within the Three Waters Wind Farm categorized by echolocation call frequency.

Common Name	Scientific Name
High-Frequency (>30 kHz)	
eastern red bat[1,4]	*Lasiurus borealis*
little brown bat[1,3]	*Myotis lucifugus*
northern long-eared bat[1,2,3]	*M. septentrionalis*
tri-colored bat[1,3]	*Perimyotis subflavus*
Low-Frequency (<30 kHz)	
big brown bat[1,3]	*Eptesicus fuscus*
silver-haired bat[1,4]	*Lasionycteris noctivagans*
hoary bat[1,4]	*Lasiurus cinereus*

[1] Species known to have been killed at wind energy facilities (American Wind Wildlife Institute 2018);

[2] federally threatened (International Union for Conservation of Nature 2018; US Fish and Wildlife Service 2018);

[3] species of special concern in Minnesota (Minnesota Department of Natural Resources 2017); and

[4] long-distance migrant

kHz = kilohertz

White-Nose Syndrome

Bats that hibernate in North America are being severely impacted by white-nose syndrome (WNS), an infectious mycosis in which bats are infected with a psychrophilic fungus from Europe (*Pseudogymnoascus* [formerly *Geomyces*] *destructans*) that is thought to act as a chronic disturbance during hibernation (USGS 2010; Minnis and Lindner 2013). Infected bats arouse frequently from hibernation, leading to premature loss of fat reserves and atypical behavior, which in turn leads to starvation prior to spring emergence (Boyles and Willis 2010; Reeder et al. 2012; Warnecke et al. 2012). WNS was first discovered in New York State in 2006 and by 2013 had rapidly spread to over 115 caves and mines and is now confirmed in 31 states and the causative fungus has been identified in an additional two states (Mississippi and Texas). To date, the full WNS has spread north into five Canadian provinces, and reaches as far south as Alabama and as far west as Washington (Heffernan, 2016). It is estimated that between 5.7 and 6.7 million bats have died as a result of WNS by 2012 (UMWS 2012). WNS is the primary reason the USFWS listed the northern long-eared bat as threatened in 2015 under the Endangered Species Act (USFWS 2015) and is the reason the little brown bat has been petitioned for listing as well. The fungus was first detected in Minnesota during the winter of 2014-2015. The closest confirmed occurrence of WNS to the Project is in Webster County, Iowa, approximately 97 mi (156 km) to the southeast of the Project.

METHODS

Bat Acoustic Surveys

The bat activity acoustic surveys were conducted to estimate the level of bat activity throughout the Project area during April 23 to October 15, 2018.

Survey Stations

AnaBat SD2 ultrasonic bat detectors (AnaBat; Titley™ Scientific, Columbia, Missouri) were used during the study. Two detectors were placed at a meteorological (met) tower, with one microphone at ground level (ground station; station TW1g; approximately 1.5 meters (m; 5.0 feet [ft] above ground level [AGL]) and another within the rotor-swept zone (raised station; station TW1r; approximately 45 m [148 ft] AGL; Figure 3). Microphones at ground stations likely detect a more complete sample of the bat species present within the Project area, whereas microphones at raised stations may give a more accurate assessment of risk to bat species flying at rotor swept heights (Kunz et al. 2007b; Collins and Jones 2009; Müeller et al. 2013; Roemer et al. 2017). The met tower stations were located in cultivated crops, which is the dominant land cover type (Table 1) and is representative of potential turbine locations (representative stations).

Two more detectors were moved between four temporary stations (stations TW2t – TW5t; Figure 3) every two weeks to increase spatial coverage at the Project. Two of these stations were placed near wetland and deciduous forest habitat attractive to foraging bats (bat feature stations; Figure 3). An experienced bat biologist selected the location of the bat feature stations. Monitoring at the bat feature stations provides an upper threshold for bat activity in the Project area for comparison with representative stations.

Each AnaBat unit was placed inside a plastic weather-tight container that had a hole cut in the side through which the microphone extended. Each microphone was encased in a 45-degree angle polyvinyl chloride (PVC) tube, and holes were drilled in the PVC tube to allow water to drain.

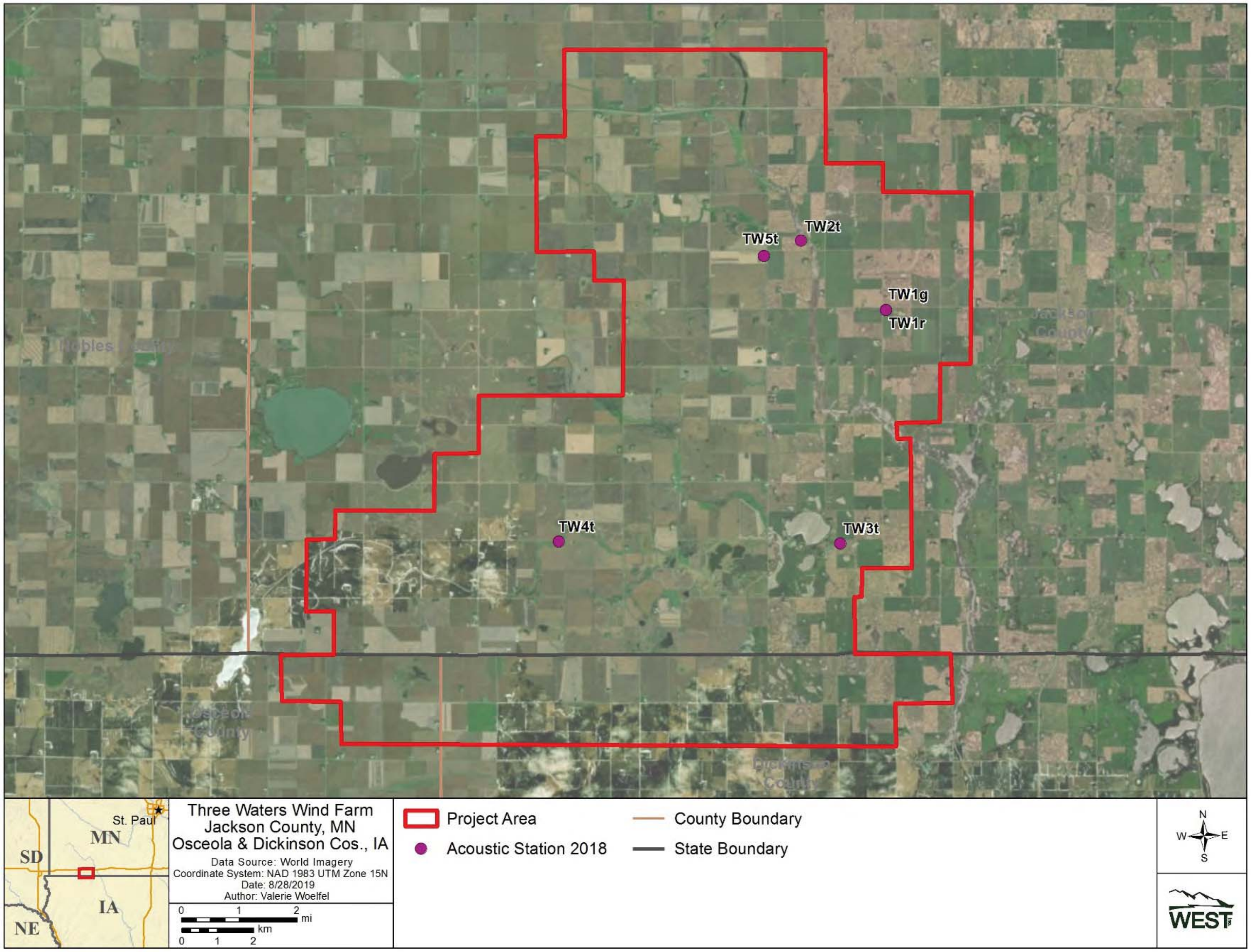

Figure 3. Location of bat monitoring stations in the Three Waters Wind Farm.

Survey Schedule

Bats were surveyed in the Project from April 23 to October 15, 2018, and detectors were programmed to turn on approximately 30 minutes (min) before sunset and turn off approximately 30 min after sunrise each night. To highlight seasonal activity patterns, the study was divided into three survey periods: spring (April 23 – May 14), summer (May 15 – August 15), and fall (August 16 – October 15). Mean bat activity was also calculated for a standardized Fall Migration Period (FMP), defined here as July 30 – October 14. The FMP was defined by WEST as a standard for comparison with activity from other wind energy facilities. During this time bats begin moving toward wintering areas, and many species of bats initiate reproductive behaviors (Cryan 2008). This period of increased landscape-scale movement and reproductive behavior is often associated with increased levels of bat fatalities at operational wind energy facilities (Arnett et al. 2008; Arnett and Baerwald 2013).

Data Collection and Call Analysis

AnaBat detectors use a broadband high-frequency microphone to detect the echolocation calls of bats. Incoming echolocation calls are digitally processed and stored on a high capacity, compact flash card. The resulting files can be viewed in appropriate software (e.g., Analook©) as digital sonograms that show changes in echolocation call frequency over time. Frequency versus time displays were used to separate bat calls from other types of ultrasonic noise (e.g., wind, insects) and to determine the call frequency category and (when possible) the species of bat that generated the calls.

To standardize acoustic sampling effort across the Project, AnaBat units were calibrated and sensitivity levels were set to six (Larson and Hayes 2000), a level that balanced the goal of recording bat calls against the need to reduce interference from other sources of ultrasonic noise (Brooks and Ford 2005).

For each survey location, bat passes were sorted into two groups based on their minimum frequency. High-frequency (HF) bats, such as eastern red bats (*Lasiurus borealis*) and *Myotis* species, have minimum frequencies greater than 30 kilohertz (kHz). Low-frequency (LF) bats, such as big brown bats, silver-haired bats (*Lasionycteris noctivagans*), and hoary bats (*Lasiurus cinereus*), typically emit echolocation calls with minimum frequencies below 30 kHz. HF and LF species that may occur in the study area are listed in Table 2

Statistical Analysis

The standard metric used for measuring bat activity is the number of bat passes per detector-night, and this metric was used as an index of bat activity in the Project area. A bat pass was defined as a sequence of at least two echolocation calls (pulses) produced by an individual bat with no pause between calls of more than one second (Fenton 1980). A detector-night was defined as one detector operating for one entire night. The terms bat pass and bat call are used interchangeably. Bat passes per detector-night was calculated for all bats, and for HF and LF bats. Bat pass rates represent indices of bat activity and do not represent numbers of individuals. The number of bat passes was determined by an experienced bat biologist using Analook.

Additionally, the calculation of bat passes per detector-night was based on the first and last bat call sequence positively identified during the study period. This removed the inclusion of operational days where no bat calls were recorded from the analysis.

The period of peak sustained bat activity was defined as the 7-day period with the highest average bat activity. If multiple 7-day periods equaled the peak sustained bat activity rate, all dates in these 7-day periods were reported. This and all multi-detector averages in this report were calculated as an unweighted average of total activity at each detector. Temporary stations were not sampled on a continuous basis throughout the survey period and were, therefore, excluded from temporal analyses. Data from the bat feature stations were also excluded from temporal analysis because seasonal changes in activity at bat feature stations likely reflects changes in insect abundance or roosting behavior, whereas activity at representative stations reflects bats commuting through the Project area.

RESULTS

Bat Acoustic Surveys

Bat activity was monitored at six sampling locations for a total of 670 detector-nights between April 23 and October 15, 2018. AnaBat units were operating for 95% of the sampling period (Figure 4). Overall, the average bat pass rate was 14.61 ± 1.39 bat passes per detector-night (Table 3).

Spatial Variation

Bat activity in the Project varied among stations (Table 3, Figure 5). Activity at the fixed representative stations was relatively low, and similar between the fixed ground (1.64 bat passes per detector-night) and the raised (1.39 bat passes per detector-night) microphones (Table 3, Figure 6). While activity at temporary ground representative stations varied, ranging between 7.07 bat passes per detector-night (station TW3t) and 20.26 bat passes per detector-night (station TW4t). Activity at bat feature stations was slightly variable, ranging between 20.74 bat passes per detector-night (station TW2t) and 36.57 bat passes per detector-night (station TW5t; Table 3, Figure 5).

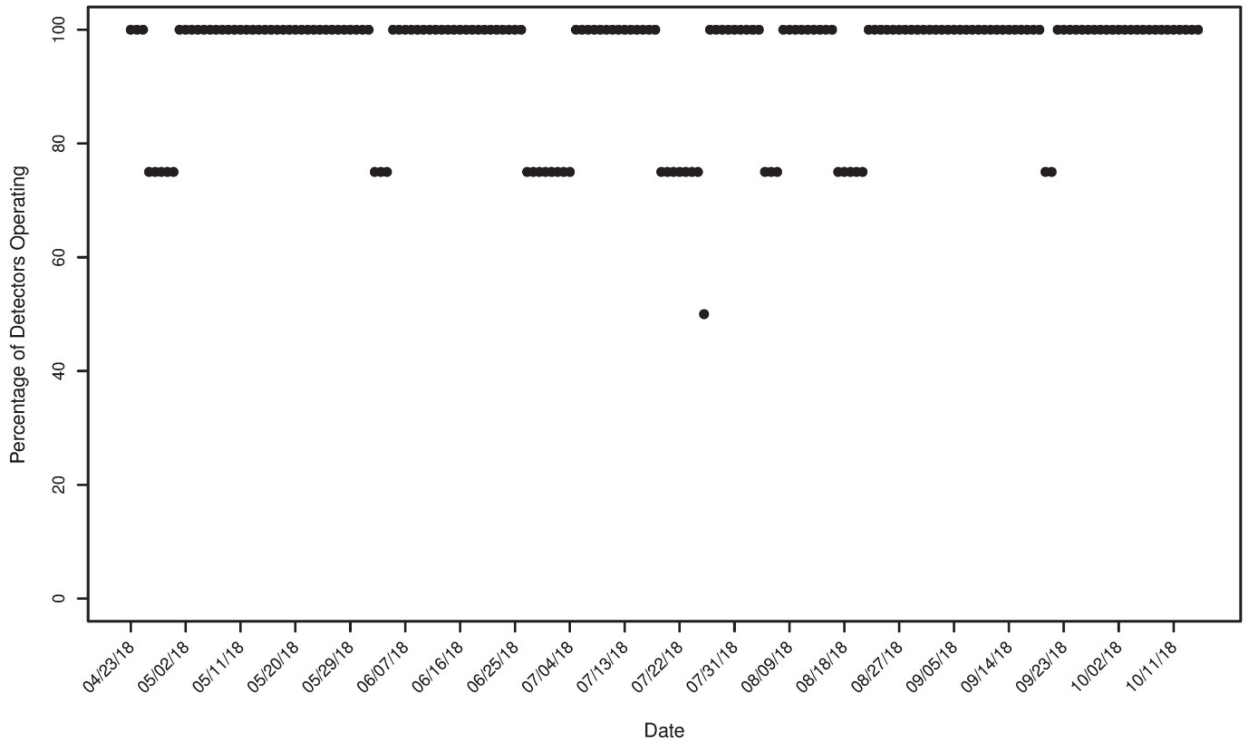

Figure 4. Operational status of bat detectors (n = 6) operating at the Three Waters Wind Farm, during each night of the survey period April 23 – October 15, 2018.

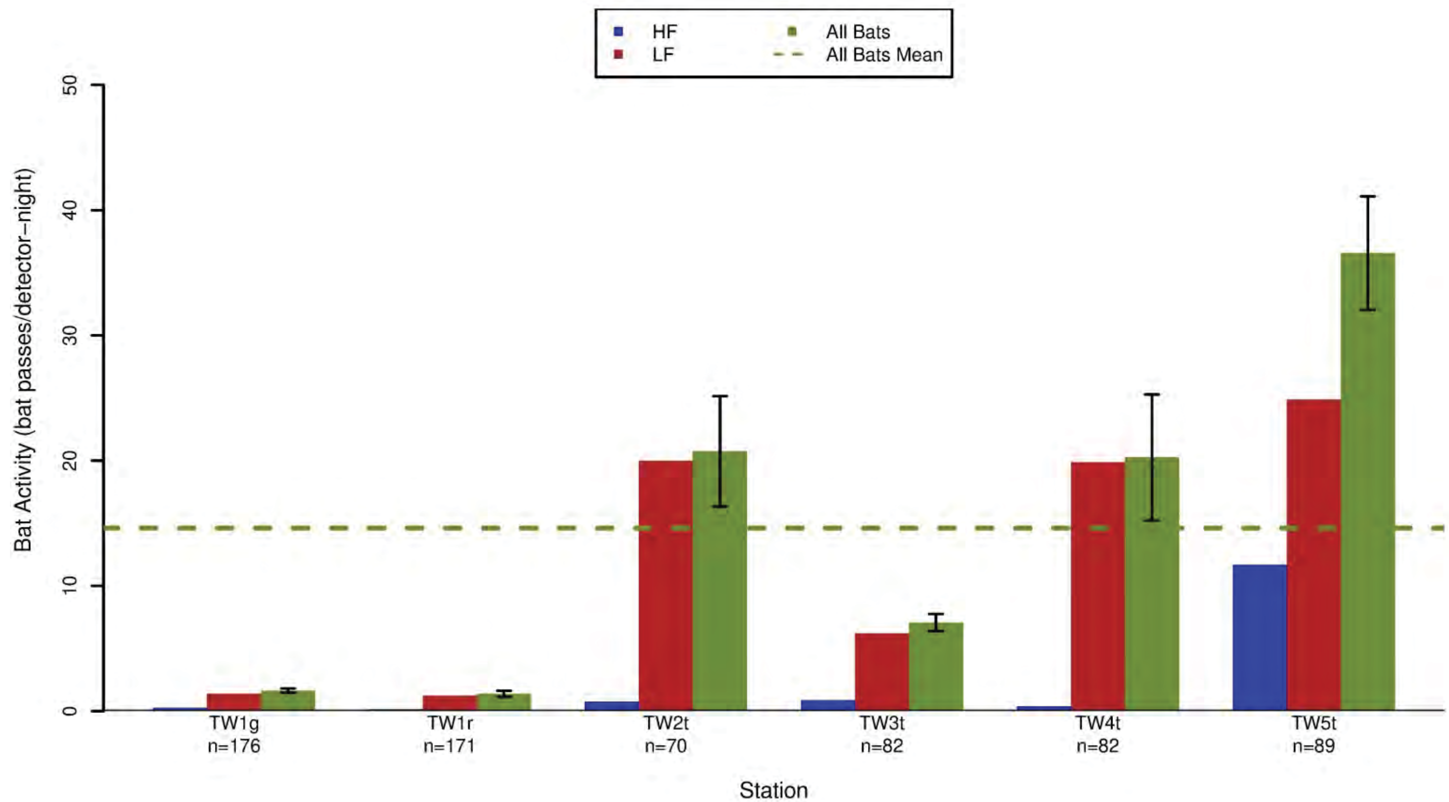

Figure 5. Number of high-frequency (HF) and low-frequency (LF) bat passes per detector-night recorded at detectors in the Three Waters Wind Farm, April 23 – October 15, 2018. The bootstrapped standard errors are represented by the black error bars on the 'All Bats' columns.

Table 3. Results of acoustic bat surveys conducted at the Three Waters Wind Farm April 23 – October 15, 2018. Passes are separated by call frequency: high-frequency and low-frequency.

Anabat			Bat Passes				Mean Bat Passes/Night
Station	Location	Type	High-Frequency	Low-Frequency	Total	Detector- Nights	(± Standard Error)*
TW1g	ground	representative	47	241	288	176	1.64 ± 0.16
TW1r	raised	representative	26	211	237	171	1.39 ± 0.24
TW2t	ground	bat feature	52	1,400	1,452	70	20.74 ± 4.41
TW3t	ground	representative	72	508	580	82	7.07 ± 0.68
TW4t	ground	representative	32	1,629	1,661	82	20.26 ± 5.03
TW5t	ground	bat feature	1,040	2,215	3,255	89	36.57 ± 4.52
Total Fixed Ground			**47**	**241**	**288**	**176**	**1.64 ± 0.15**
Total Fixed Raised			**26**	**211**	**237**	**171**	**1.39 ± 0.24**
Total Temporary Ground Temporary			**1,196**	**5,752**	**6,948**	**323**	**21.16 ± 1.96**
Total			**1,269**	**6,204**	**7,473**	**670**	**14.61 ± 1.39**

* ± bootstrapped standard error.

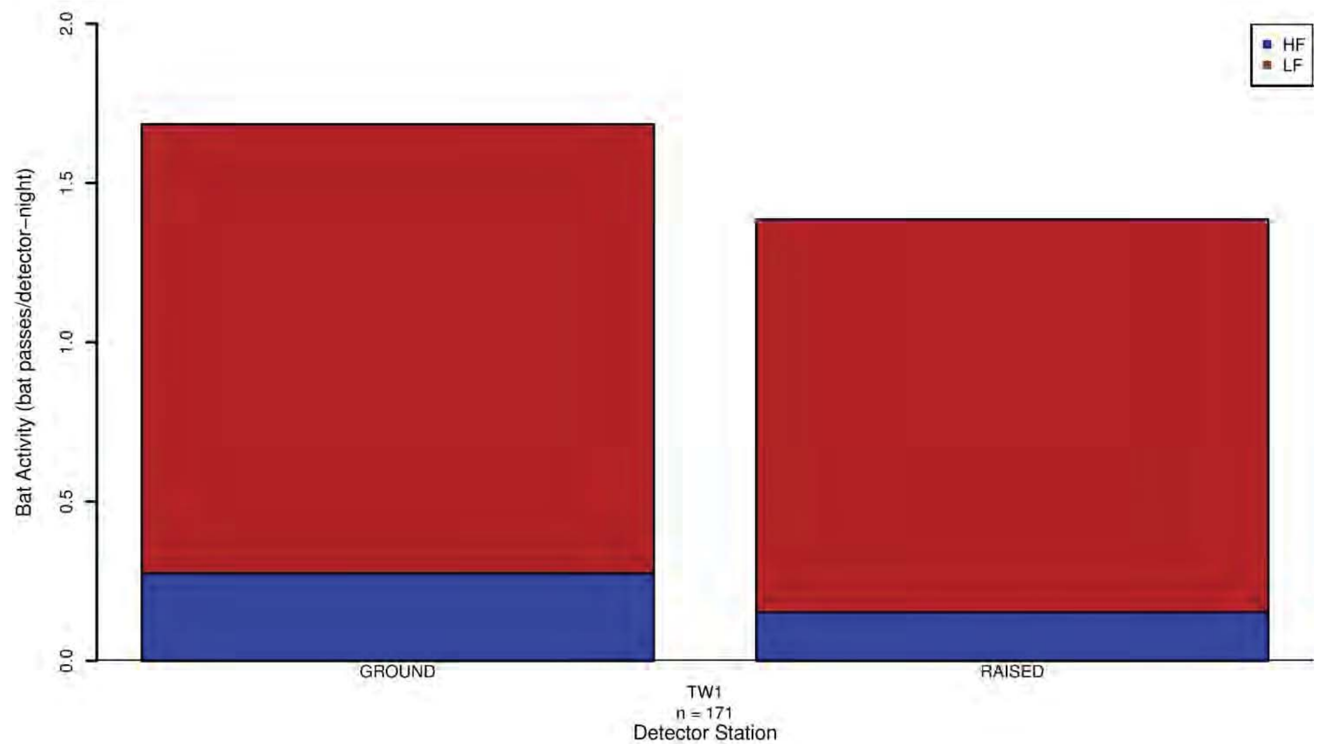

Figure 6. Number of high-frequency (HF) and low-frequency (LF) bat passes per detector-night recorded at paired stations in the Three Waters Wind Farm April 23 – October 15, 2018.

Temporal Variation

Bat activity at the fixed stations was similar among seasons, ranging between 0.64 bat passes per detector-night in the spring to 1.94 bat passes per detector-night in the fall (Table 4, Figure 7). The bat pass rate for the fixed ground detector during the standardized FMP was 2.03 bat passes per detector-night (Table 4). Weekly acoustic activity at the fixed stations was relatively low for much of the study period (Figure 8), peaking from August 20 to August 26 (4.50 bat passes per detector-night; Table 5). Bat activity was also high the first week of October (Figure 8), which was mainly detected at the raised microphone (Figure 9). Otherwise, bat activity at the ground and raised microphones were fairly similar throughout the study period (Figure 9).

Table 4. The number of bat passes per detector-night recorded at fixed stations in the Three Waters Wind Farm during each season, separated by call frequency: high-frequency (HF), low-frequency (LF), and all bats (AB).

Station	Call Frequency	Spring April 23 – May 14	Summer May 15 – August 15	Fall August 16 – October 15	Fall Migration Period July 30 – October 14
TW1g	LF	0.86	1.38	1.54	1.62
	HF	0	0.31	0.3	0.40
	AB	0.86	1.69	1.84	2.03
TW1r	LF	0.41	1.01	1.8	1.88
	HF	0	0.12	0.25	0.27
	AB	0.41	1.13	2.05	2.16
Overall	**LF**	**0.64 ± 0.30**	**1.19 ± 0.11**	**1.67 ± 0.38**	**1.75 ± 0.30**
	HF	**0.00 ± 0.00**	**0.22 ± 0.04**	**0.27 ± 0.06**	**0.34 ± 0.06**
	AB	**0.64 ± 0.30**	**1.41 ± 0.13**	**1.94 ± 0.38**	**2.09 ± 0.31**

* Sums may not equal totals shown due to rounding.

Table 5. Periods of peak activity for low-frequency (LF) and all bats at representative stations within the Three Waters Wind Farm April 23 – October 15, 2018.

Species Group	Start Date of Peak Activity	End Date of Peak Activity	Bat Passes per Detector-Night
LF	August 20	August 26	3.93
All Bats	August 20	August 26	4.50

Note: Peak activity was not calculated for HF bats due to low activity rates (<1.0 bat passes per detector-night).

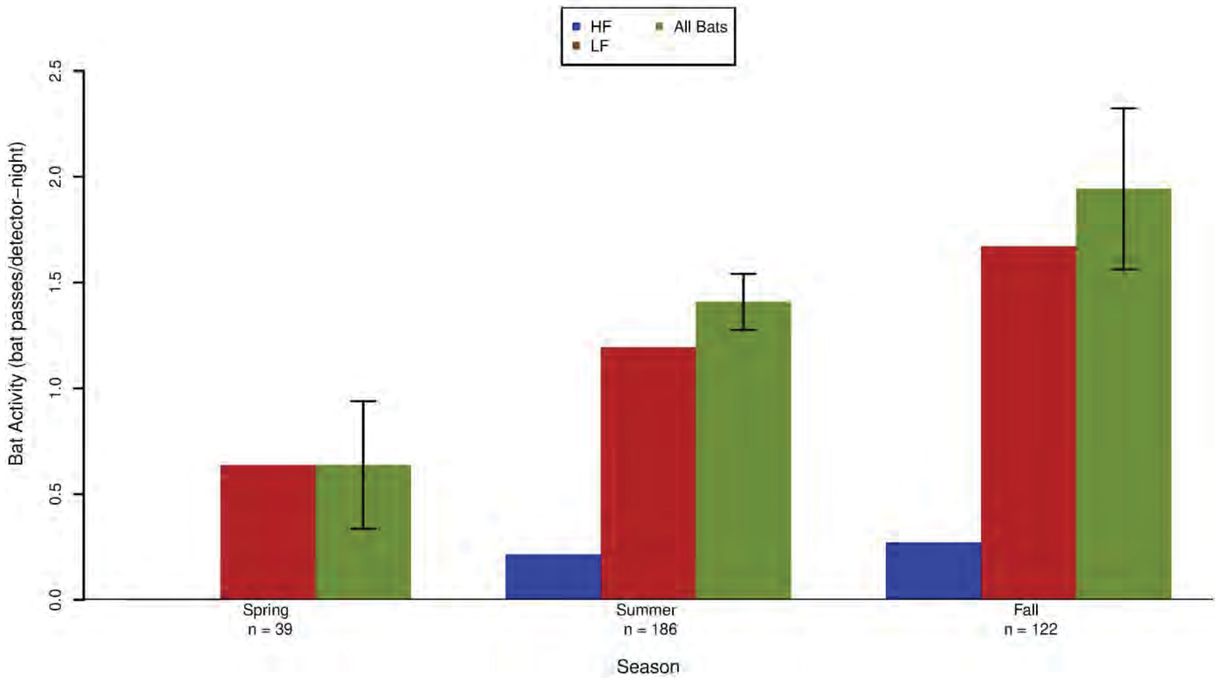

Figure 7. Mean seasonal bat activity by frequency for representative acoustic monitoring stations at the Three Waters Wind Farm, April 23 – October 15, 2018. The bootstrapped standard errors are represented on the 'All Bats' columns. HF = high-frequency; LF = low-frequency.

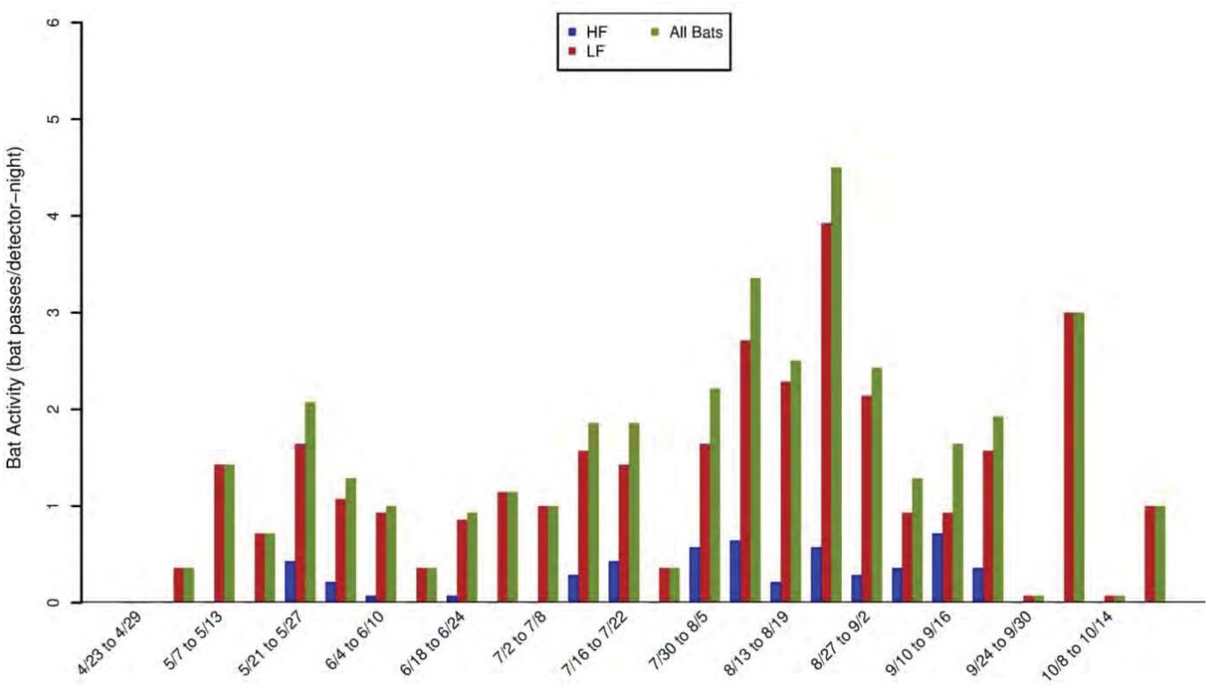

Figure 8. Weekly patterns of bat activity (bat passes) by high-frequency (HF), low-frequency (LF), and All bats at representative monitoring stations within the Three Waters Wind Farm, April 23 – October 15, 2018.

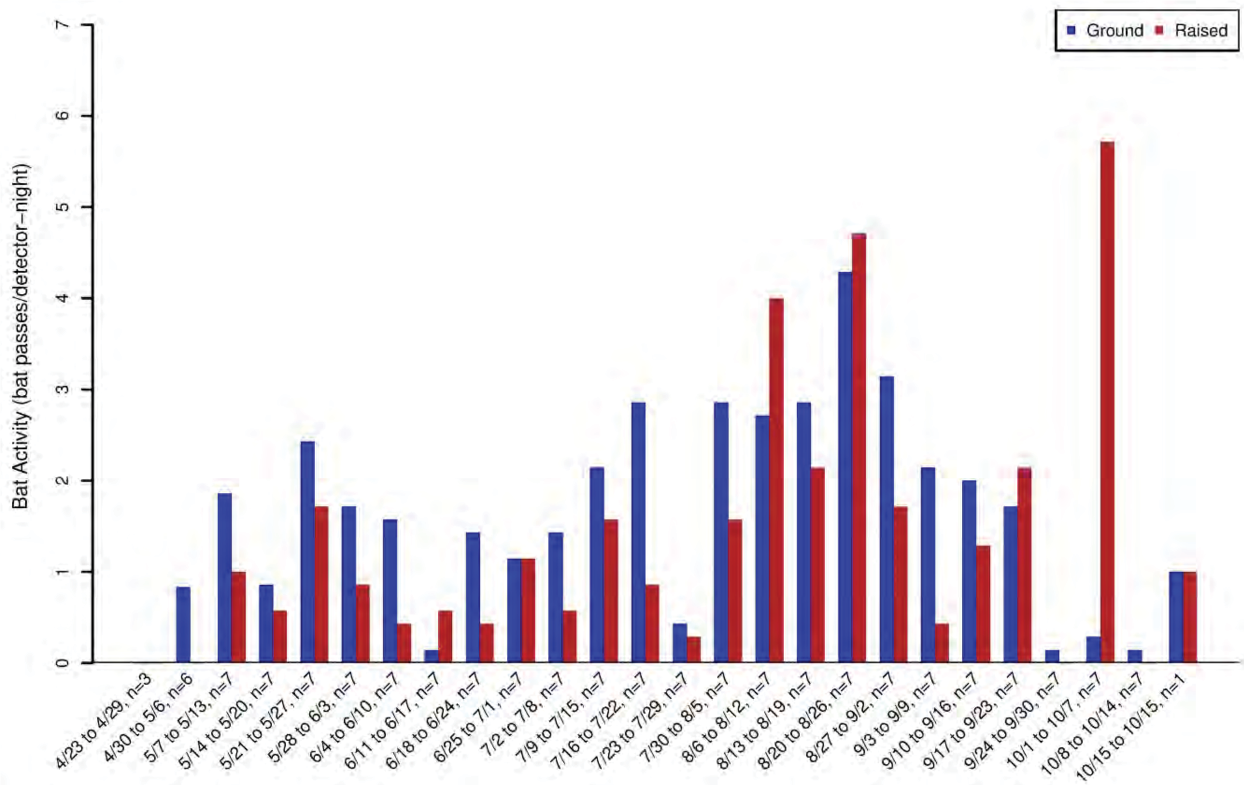

Figure 9. Weekly patterns of bat activity April 23 – October 15, 2018, at ground and raised fixed stations at the Three Waters Wind Farm.

Species Composition

At all stations, 83.0% of bat passes were classified as LF (e.g., big brown bats, hoary bats, and silver-haired bats), and 17.0% of bat passes were classified as HF (e.g., eastern red bats and *Myotis* species; Tables 2 and 3). These proportions were similar among both fixed and temporary stations (Table 3), and between the ground and raised fixed station (Table 3).

DISCUSSION

Bat fatalities have been discovered at most wind energy facilities monitored in North America, with fatality estimates ranging from 0 to 49.70 bat fatalities/megawatt (MW)/year (American Wind Wildlife Institute [AWWI] 2018). A summary of 202 studies at 137 wind energy facilities in the US found the majority of wind energy facilities reported fewer than five bat fatalities/MW/year, with a nationwide median of 2.66 bat fatalities/MW/year (AWWI 2018). In 2012, an estimated 600,000 bats died as a result of interactions with wind turbines in the US (Hayes 2018). Wind development may pose a threat to populations of migratory bats in particular. Projection models estimate populations of hoary bats could decline as much as 90% in the next 50 years (Frick et al. 2017). Proximate causes of bat fatalities are primarily due to collisions with moving turbine blades (Grodsky et al. 2011, Rollins et al. 2012), but also, to a limited extent, by barotrauma (Baerwald et al. 2008). The underlying reason(s) why bats come near turbines is still largely unknown (Cryan and Barclay 2009, Barclay et al. 2017).

To date, post-construction monitoring studies of wind energy facilities in the US show the following: a) migratory tree-roosting species (e.g., eastern red bat, hoary bat, and silver-haired bat) compose approximately 72% of reported bat fatalities; b) the majority of fatalities occur during the fall migration season (August and September); and c) most fatalities occur on nights with relatively low wind speeds (e.g., <6.0 meters/second; Arnett et al. 2008, Arnett and Baerwald 2013, Arnett et al. 2013, AWWI 2018, Thompson et al. 2017).

Few studies of wind energy facilities are available that have recorded both bat activity and bat fatality rates (Appendix A). Hein et al. (2013a) compiled data from 12 wind projects that measured bat activity and fatality rates and found a non-significant ($p = 0.07$), positive correlation where low activity was generally associated with low fatalities and vice-versa. Researchers concluded pre-construction acoustic data could not currently predict bat fatalities, but acknowledged the data set was limited and additional data may indicate a stronger relationship. Complicating matters, recent evidence suggests the main species killed at wind turbines, hoary bats, often fly without echolocation (Corcoran and Weller 2018) and are therefore not recorded on ultrasonic detectors. However, Baerwald and Barclay (2009) found a significant positive association between pass rates measured at 30 m (98 ft) and fatality rates for hoary and silver-haired bats across five sites in southern Alberta. Yet, on a continental scale, a similar relationship has proven difficult to establish.

A review of 40 US studies found bat mortality might be inversely related to the percent grassland cover surrounding wind facilities (Thompson et al. 2017). That is, the more open the landscape, the less risk of turbine collisions by bats. However, exceptions to this pattern exist (e.g., Jain 2005, Arnett and Baerwald 2013) and it may not be applicable to all regions (Thompson et al. 2017). Bat activity in the rotor-swept zone is representative of bat exposure to turbines (Baerwald and Barclay 2009, Collins and Jones 2009, Roemer et al. 2017), but it is unclear how bat activity at raised stations might relate to bat fatality, or even if such a relationship exists.

Mean bat activity during the FMP at fixed ground detectors (2.03 bat passes per detector-night; Table 4) was lower than the national median bat activity (7.68 bat passes per detector-night) and the majority of studies available from the Midwest (Appendix A). Overall bat activity was highest within the Project area during the fall, peaking in late August. In 2017, bat activity during the FMP was similarly low (4.72 bat passes per detector-night), and activity was highest in the summer, peaking in mid-August (Sichmeller and Solick 2018). This timing is consistent with peak fatality periods for most wind energy facilities in the US (AWWI 2018), and suggests bat fatalities at the Project will be highest during late summer to early fall.

Activity by HF bat species composed 17% of bat passes recorded at all stations in the Project area. Eastern red bats are usually the most common HF species found during carcass searches (Arnett et al. 2008, Arnett and Baerwald 2013, AWWI 2018). *Myotis* species are recorded less commonly than other species in the rotor-swept zone or as fatalities at most post-construction studies of wind energy facilities (Kunz et al. 2007b, Arnett et al. 2008, AWWI 2018), with a few notable exceptions (Kerns and Kerlinger 2004, Jain 2005, Brown and Hamilton 2006, Gruver et al. 2009).

Approximately 83% of bat passes recorded in the Project area were emitted by LF bats. LF bat species may become casualties because they fly at higher altitudes, as demonstrated by their greater prevalence at raised detectors (Table 3, Figure 6). Given that hoary bats, eastern red bats, and silver-haired bats are among the most common bat fatalities at many facilities (Arnett et al. 2008, Arnett and Baerwald 2013, AWWI 2018), it is expected these three species would be the most common fatalities at the Project.

Over two-thirds of bat fatality studies in the Midwest report fewer than five bat fatalities/MW/year (Appendix A, Figure 10). It is possible similar fatality rates could be recorded at the Project. Mean bat activity at the Project was also lower than activity recorded at the Lakefield Wind Project, located 8.5 km (5.3 mi) to the northeast. At Lakefield, bat activity was surveyed from April 1 to October 31 in 2011 using ground and raised AnaBat detectors at two met towers. One of the ground detectors recorded 10.40 bat passes per detector-night, and the other recorded 13.08 bat passes per detector-night (Minnesota Public Utilities Commission (MPUC) 2012). In 2012, bat activity was monitored concurrently with post-construction monitoring from March 31 to October 31, and the bat pass rates at ground detectors were 7.94 and 14.77 bat passes per detector-night (Westwood Professional Services (Westwood) 2013). In both years, peak bat activity occurred between mid-July and early September, and LF bats were the main species recorded (MPUC 2012, Westwood 2013), consistent with this study. Post-construction monitoring at Lakefield in 2012 and in 2014 determined estimated bat fatality rates of 19.87 and 20.19 bats/MW, respectively, with peak bat mortality for hoary, eastern red, and silver-haired bats occurring between mid-July and mid-September in both years (Westwood 2013, 2015). Given the proximity of the Project to Lakefield, it is likely similar patterns in fatality could be recorded at the Project. Due to the lower bat activity rates at the Project, the bat fatality rates are likely to be less than 20 bats/MW/year.

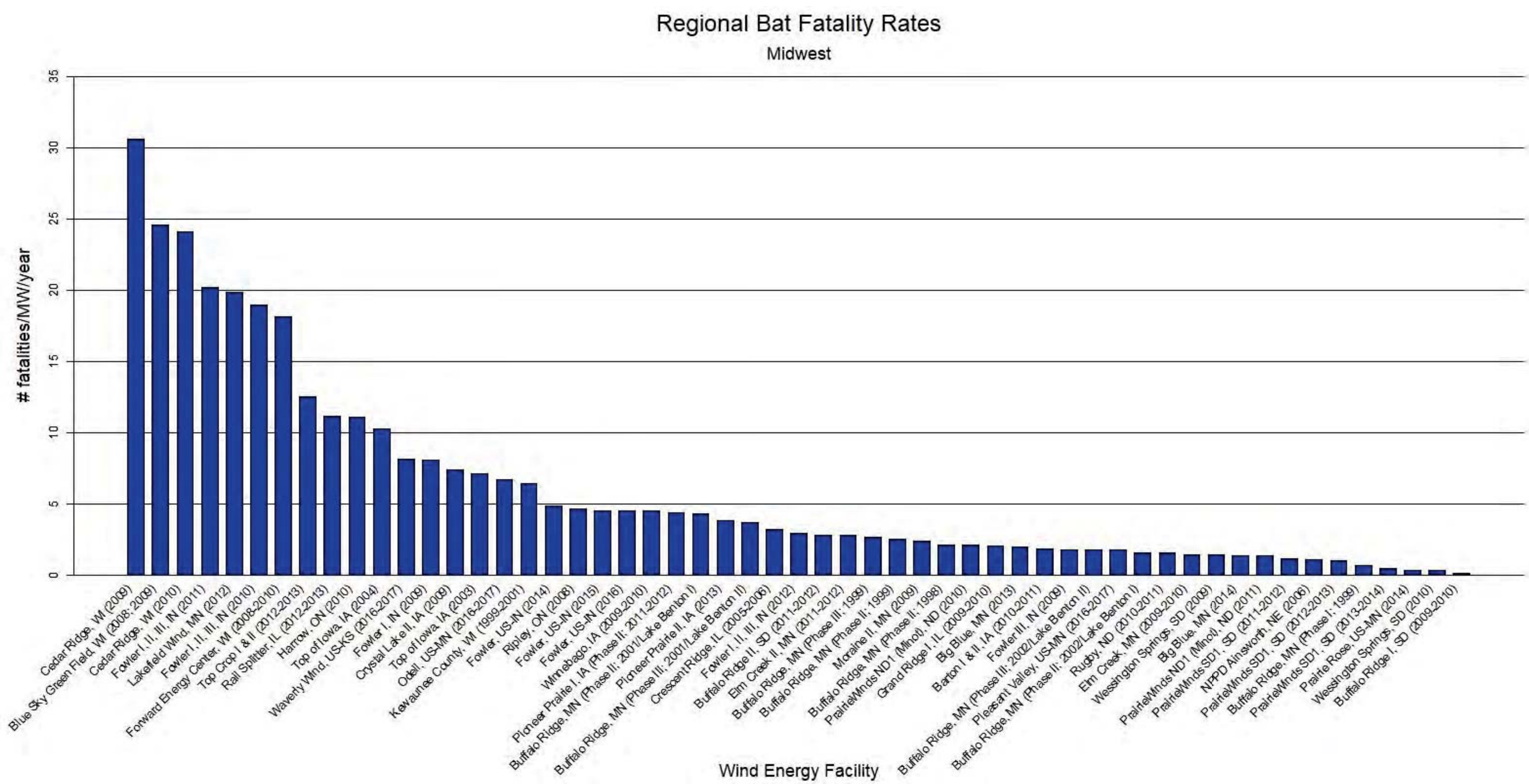

Figure 10. Fatality rates for bats (number of bats per MW per year) from publicly-available studies at wind energy facilities in the Midwest regions of North America.

Figure 10 (*continued*). Fatality rates for bats (number of bats per megawatts per year) from publically available wind energy facilities in the Midwest region of North America. Data from the following sources:

Facility Study	Bat Fatality	Fatality Estimate Citation
Three Waters, MN		**This study**
Cedar Ridge, WI (2009)	30.61	BHE Environ-mental 2010
Blue Sky Green Field, WI (2008; 2009)	24.57	Gruver et al. 2009
Cedar Ridge, WI (2010)	24.12	BHE Environ-mental 2011
Fowler I, II, III, IN (2011)	20.19	Good et al. 2012
Lakefield Wind, MN (2012)	19.87	Minnesota Public Utilities Commission 2012
Fowler I, II, III, IN (2010)	18.96	Good et al. 2011
Forward Energy Center, WI (2008-2010)	18.17	Grodsky and Drake 2011
Top Crop I & II (2012-2013)	12.55	Good et al. 2013c
Rail Splitter, IL (2012-2013)	11.21	Good et al. 2013b
Harrow, Ont (2010)	11.13	Natural Resources Solutions Inc. (NRSI) 2011
Top of Iowa, IA (2004)	10.27	Jain 2005
Waverly Wind, US-KS (2016-2017)	8.2	Tetra Tech 2017a
Fowler I, IN (2009)	8.09	Johnson et al. 2010a
Crystal Lake II, IA (2009)	7.42	Derby et al. 2010b
Top of Iowa, IA (2003)	7.16	Jain 2005
Odell, US-MN (2016-2017)	6.74	Chodachek and Gustafson 2018
Kewaunee County, WI (1999-2001)	6.45	Howe et al. 2002
Fowler, US-IN (2014)	4.86	Good et al. 2015
Ripley, Ont (2008)	4.67	Jacques Whitford 2009
Fowler, US-IN (2015)	4.54	Good et al. 2016
Fowler, US-IN (2016)	4.54	Good et al. 2017
Winnebago, IA (2009-2010)	4.54	Derby et al. 2010a
Pioneer Prairie I, IA (Phase II; 2011-2012)	4.43	Chodachek et al. 2012
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	4.35	Johnson et al. 2004
Pioneer Prairie II, IA (2013)	3.83	Chodachek et al. 2014
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	3.71	Johnson et al. 2004
Crescent Ridge, IL (2005-2006)	3.27	Kerlinger et al. 2007
Fowler I, II, III, IN (2012)	2.96	Good et al. 2013a
Buffalo Ridge II, SD (2011-2012)	2.81	Derby et al. 2012a
Elm Creek II, MN (2011-2012)	2.81	Derby et al. 2012b
Buffalo Ridge, MN (Phase III; 1999)	2.72	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1999)	2.59	Johnson et al. 2000
Moraine II, MN (2009)	2.42	Derby et al. 2010f
Buffalo Ridge, MN (Phase II; 1998)	2.16	Johnson et al. 2000
PrairieWinds ND1 (Minot), ND (2010)	2.13	Derby et al. 2011d
Grand Ridge I, IL (2009-2010)	2.1	Derby et al. 2010a
Big Blue, MN (2013)	2.04	Fagen Engineering 2014
Barton I & II, IA (2010-2011)	1.85	Derby et al. 2011b
Fowler III, IN (2009)	1.84	Johnson et al. 2010b
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.81	Johnson et al. 2004
Pleasant Valley, US-MN (2016-2017)	1.8	Tetra Tech 2017b
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.64	Johnson et al. 2004
Rugby, ND (2010-2011)	1.6	Derby et al. 2011c
Elm Creek, MN (2009-2010)	1.49	Derby et al. 2010e
Wessington Springs, SD (2009)	1.48	Derby et al. 2010c
Big Blue, MN (2014)	1.43	Fagen Engineering 2015

Figure 10 (*continued*). Fatality rates for bats (number of bats per megawatts per year) from publically available wind energy facilities in the Midwest region of North America. Data from the following sources:

Facility Study	Bat Fatality	Fatality Estimate Citation
Three Waters, MN		**This study**
PrairieWinds ND1 (Minot), ND (2011)	1.39	Derby et al. 2012d
PrairieWinds SD1, SD (2011-2012)	1.23	Derby et al. 2012c
NPPD Ainsworth, NE (2006)	1.16	Derby et al. 2007
PrairieWinds SD1, SD (2012-2013)	1.05	Derby et al. 2013a
Buffalo Ridge, MN (Phase I; 1999)	0.74	Johnson et al. 2000
PrairieWinds SD1, SD (2013-2014)	0.52	Derby et al. 2014
Prairie Rose, US-MN (2014)	0.41	Chodachek et al. 2015
Wessington Springs, SD (2010)	0.41	Derby et al. 2011a
Buffalo Ridge I, SD (2009-2010)	0.16	Derby et al. 2010d

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Young, D. P., Jr., M. Lout, Z. Courage, S. Nomani, and K. Bay. 2012b. 2011 Post-Construction Monitoring Study, Criterion Wind Project, Garrett County, Maryland: April - November 2011. Prepared for Criterion Power Partners, LLC, Oakland, Maryland. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Waterbury, Vermont. April 20, 2012. Revised November 25, 2013.

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Young, D. P., Jr., M. Kauffman, M. Lout, and K. Bay. 2014b. 2013 Post-Construction Monitoring Study, Criterion Wind Project, Garrett County, Maryland. April - November 2013. Prepared for Criterion Power Partners, LLC, Oakland, Maryland. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, and Waterbury, Vermont. February 18, 2014.

Appendix A: North American Fatality Summary Tables

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the number of bat passes per detector night. Fatality estimate given as the number of bat fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Three Waters, Minnesota 2018	**2.09**	7/30/18-10/14/18			
Three Waters, Minnesota 2017	**4.72**	7/30/17-10/14/17			
Midwest					
Cedar Ridge, WI (2009)	9.97[A,B,C,D]	7/16/07-9/30/07	30.61	41	67.6
Blue Sky Green Field, WI (2008; 2009)	7.7[D]	7/24/07-10/29/07	24.57	88	145
Cedar Ridge, WI (2010)	9.97[A,B,C,D]	7/16/07-9/30/07	24.12	41	68
Fowler I, II, III, IN (2011)	NA	NA	20.19	355	600
Lakefield Wind, MN (2012)	NA	NA	19.87	137	205.5
Fowler I, II, III, IN (2010)	NA	NA	18.96	355	600
Forward Energy Center, WI (2008-2010)	6.97	8/5/08-11/08/08	18.17	86	129
Top Crop I & II (2012-2013)	NA	NA	12.55	200 (68 Phase I, 132 Phase II)	300 (102 Phase I, 198 Phase II)
Rail Splitter, IL (2012-2013)	NA	NA	11.21	67	100.5
Harrow, Ont (2010)	NA	NA	11.13	24 (four 6-turbine facilities)	39.6
Top of Iowa, IA (2004)	35.7	5/26/04-9/24/04	10.27	89	80
Waverly Wind, KS (2016-2017)	NA	NA	8.2	95	199
Fowler I, IN (2009)	NA	NA	8.09	162	301
Crystal Lake II, IA (2009)	NA	NA	7.42	80	200
Top of Iowa, IA (2003)	NA	NA	7.16	89	80
Odell, MN (2016-2017)	NA	NA	6.74	100	200
Kewaunee County, WI (1999-2001)	NA	NA	6.45	31	20.46
Fowler, IN (2014)	NA	NA	4.86	355	600
Ripley, Ont (2008)	NA	NA	4.67	38	76
Winnebago, IA (2009-2010)	NA	NA	4.54	10	20
Fowler, IN (2016)	NA	NA	4.54	420	750
Fowler, IN (2015)	NA	NA	4.54	420	NA
Pioneer Prairie I, IA (Phase II; 2011-2012)	NA	NA	4.43	62	102.3
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	2.2[B]	6/15/01-9/15/01	4.35	143	107.25
Pioneer Prairie II, IA (2013)	NA	NA	3.83	62	102.3
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	2.2[B]	6/15/01-9/15/01	3.71	138	103.5
Crescent Ridge, IL (2005-2006)	NA	NA	3.27	33	49.5
Fowler I, II, III, IN (2012)	NA	NA	2.96	355	600
Elm Creek II, MN (2011-2012)	NA	NA	2.81	62	148.8
Buffalo Ridge II, SD (2011-2012)	NA	NA	2.81	105	210
Buffalo Ridge, MN (Phase III; 1999)	NA	NA	2.72	138	103.5
Buffalo Ridge, MN (Phase II; 1999)	NA	NA	2.59	143	107.25

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the number of bat passes per detector night. Fatality estimate given as the number of bat fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Moraine II, MN (2009)	NA	NA	2.42	33	49.5
Buffalo Ridge, MN (Phase II; 1998)	NA	NA	2.16	143	107.25
PrairieWinds ND1 (Minot), ND (2010)	NA	NA	2.13	80	115.5
Grand Ridge I, IL (2009-2010)	NA	NA	2.1	66	99
Big Blue, MN (2013)	NA	NA	2.04	18	36
Barton I & II, IA (2010-2011)	NA	NA	1.85	80	160
Fowler III, IN (2009)	NA	NA	1.84	60	99
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.9[B]	6/15/02-9/15/02	1.81	138	103.5
Pleasant Valley, MN (2016-2017)	NA	NA	1.8	100	200
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.9[B]	6/15/02-9/15/02	1.64	143	107.25
Rugby, ND (2010-2011)	NA	NA	1.6	71	149
Elm Creek, MN (2009-2010)	NA	NA	1.49	67	100
Wessington Springs, SD (2009)	NA	NA	1.48	34	51
Big Blue, MN (2014)	NA	NA	1.43	18	36
PrairieWinds ND1 (Minot), ND (2011)	NA	NA	1.39	80	115.5
PrairieWinds SD1, SD (2011-2012)	NA	NA	1.23	108	162
NPPD Ainsworth, NE (2006)	NA	NA	1.16	36	20.5
PrairieWinds SD1, SD (2012-2013)	NA	NA	1.05	108	162
Buffalo Ridge, MN (Phase I; 1999)	NA	NA	0.74	73	25
PrairieWinds SD1, SD (2013-2014)	NA	NA	0.52	108	162
Prairie Rose, MN (2014)	NA	NA	0.41	119	200
Wessington Springs, SD (2010)	NA	NA	0.41	34	51
Buffalo Ridge I, SD (2009-2010)	NA	NA	0.16	24	50.4
Rocky Mountains					
Summerview, Alb (2006; 2007)	7.65[A]	07/15/06-07-09/30/06-07	11.42	39	70.2
Summerview, Alb (2005-2006)	NA	NA	10.27	39	70.2
Judith Gap, MT (2006-2007)	NA	NA	8.93	90	135
Foote Creek Rim I, WY (1999)	NA	NA	3.97	69	41
Judith Gap, MT (2009)	NA	NA	3.2	90	135
Top of the World, WY (2010-2011)	NA	NA	2.74	110	200
Top of the World, WY (2011-2012)	NA	NA	2.43	110	200
Top of the World, WY (2012-2013)	NA	NA	2.34	110	200
Milford I, UT (2010-2011)	NA	NA	2.05	58	145
Milford I & II, UT (2011-2012)	NA	NA	1.67	107	160.5 (58.5 I, 102 II)

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the number of bat passes per detector night. Fatality estimate given as the number of bat fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Foote Creek Rim I, WY (2001-2002)	2.2[B,C]	6/15/01-9/1/01	1.57	69	41
Foote Creek Rim I, WY (2000)	2.2[B,C]	6/15/00-9/1/00	1.05	69	41
		Northeast			
Pinnacle, WV (2012)	NA	NA	40.2	23	55.2
Mountaineer, WV (2003)	NA	NA	31.69	44	66
Mount Storm, WV (2009)	30.09	7/15/09-10/7/09	17.53	132	264
Noble Wethersfield, NY (2010)	NA	NA	16.3	84	126
Criterion, MD (2011)	NA	NA	15.61	28	70
Mount Storm, WV (2010)	36.67[E]	4/18/10-10/15/10	15.18	132	264
Locust Ridge, PA (Phase II; 2010)	NA	NA	14.38	51	102
Locust Ridge, PA (Phase II; 2009)	NA	NA	14.11	51	102
Casselman, PA (2008)	NA	NA	12.61	23	34.5
Maple Ridge, NY (2006)	NA	NA	11.21	120	198
Cohocton/Dutch Hills, NY (2010)	NA	NA	10.32	50	125
Howard, NY (2012)	NA	NA	10	27	54
Wolfe Island, Ont (July-December 2010)	NA	NA	9.5	86	197.8
Cohocton/Dutch Hill, NY (2009)	NA	NA	8.62	50	125
Casselman, PA (2009)	NA	NA	8.6	23	34.5
Noble Bliss, NY (2008)	NA	NA	7.8	67	100
Criterion, MD (2012)	NA	NA	7.62	28	70
Mount Storm, WV (2011)	NA	NA	7.43	132	264
Maple Ridge, NY (2012)	NA	NA	7.3	195	321.75
Mount Storm, WV (Fall 2008)	35.2	7/20/08-10/12/08	6.62	82	164
Maple Ridge, NY (2007)	NA	NA	6.49	195	321.75
Wolfe Island, Ont (July-December 2009)	NA	NA	6.42	86	197.8
Roth Rock, MD (2011)	NA	NA	6.24	20	50
Steel Winds I & II, NY (2013)	NA	NA	6.14	14	35
Criterion, MD (2013)	NA	NA	5.32	28	70
Maple Ridge, NY (2007-2008)	NA	NA	4.96	195	321.75
Noble Clinton, NY (2009)	1.9[A]	8/1/09-09/31/09	4.5	67	100
Casselman Curtailment, PA (2008)	NA	NA	4.4	23	35.4
Noble Altona, NY (2010)	NA	NA	4.34	65	97.5
Noble Ellenburg, NY (2009)	16.1[A]	8/16/09-09/15/09	3.91	54	80
Noble Bliss, NY (2009)	NA	NA	3.85	67	100
Lempster, NH (2010)	NA	NA	3.57	12	24
Noble Ellenburg, NY (2008)	NA	NA	3.46	54	80
Noble Clinton, NY (2008)	2.1[A]	8/8/08-09/31/08	3.14	67	100
Lempster, NH (2009)	NA	NA	3.11	12	24
Record Hill, ME (2012)	24.6	4/16/12-10/23/12	2.96	22	50.6
Mars Hill, ME (2007)	NA	NA	2.91	28	42
Wolfe Island, Ont (July-December 2011)	NA	NA	2.49	86	197.8
Noble Chateaugay, NY (2010)	NA	NA	2.44	71	106.5
High Sheldon, NY (2010)	NA	NA	2.33	75	112.5
Stetson Mountain II, ME (2012)	NA	NA	2.27	17	25.5

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the number of bat passes per detector night. Fatality estimate given as the number of bat fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Howard, NY (2013)	NA	NA	2.13	27	54
Beech Ridge, WV (2012)	NA	NA	2.03	67	100.5
Munnsville, NY (2008)	NA	NA	1.93	23	34.5
High Sheldon, NY (2011)	NA	NA	1.78	75	112.5
Groton, NH (2015)	NA	NA	1.74	24	48
Stetson Mountain II, ME (2010)	NA	NA	1.65	17	25.5
Groton, NH (2014)	NA	NA	1.63	24	48
Bull Hill, ME (2013)	NA	NA	1.62	19	34
Stetson Mountain I, ME (2009)	28.5; 0.3[F]	7/10/09-10/15/09	1.4	38	57
Cohocton/Dutch Hill, NY (2013)	NA	NA	1.37	50	125
Groton, NH (2013)	NA	NA	1.31	24	48
Record Hill, ME (2016)	NA	NA	1.25	22	51
Stetson II, ME (2014)	NA	NA	0.83	17	26
Beech Ridge, WV (2013)	NA	NA	0.58	67	100.5
Record Hill, ME (2014)	NA	NA	0.55	22	50.6
Oakfield, ME (2017)	NA	NA	0.51	48	148
Mars Hill, ME (2008)	NA	NA	0.45	28	42
Rollins, ME (2014)	NA	NA	0.33	40	60
Spruce Mountain Wind Project, ME (2014)	NA	NA	0.31	10	20
Hancock, ME (2017)	NA	NA	0.3	17	51
Stetson Mountain I, ME (2011)	NA	NA	0.28	38	57
Bingham Wind Project, ME (2017)	NA	NA	0.23	56	185
Rollins, ME (2012)	NA	NA	0.18	40	60
Stetson Mountain I, ME (2013)	NA	NA	0.18	38	57
Kibby, ME (2011)	NA	NA	0.12	44	132
Southeast					
Buffalo Mountain, TN (2005)	NA	NA	39.7	18	28.98
Buffalo Mountain, TN (2000-2003)	23.7[C]	NA	31.54	3	1.98
Southern Plains					
Barton Chapel, TX (2009-2010)	NA	NA	3.06	60	120
Big Smile, OK (2012-2013)	NA	NA	2.9	66	132
Buffalo Gap II, TX (2007-2008)	NA	NA	0.14	155	233
Red Hills, OK (2012-2013)	NA	NA	0.11	82	123
Buffalo Gap I, TX (2006)	NA	NA	0.1	67	134
Southwest					
Spring Valley, NV (2012-2013)	NA	NA	3.73	66	152
Dry Lake I, AZ (2009-2010)	8.8	4/29/10-11/10/10	3.43	30	63
Dry Lake II, AZ (2011-2012)	11.5	5/11/11-10/26/11	1.66	31	65
California					
Hatchet Ridge, CA (2012)	NA	NA	5.22	44	101
Hatchet Ridge, CA (2012-2013)	NA	NA	4.2	44	NA
Shiloh I, CA (2006-2009)	NA	NA	3.92	100	150
Shiloh II, CA (2010-2011)	NA	NA	3.8	75	150
Shiloh II, CA (2011-2012)	NA	NA	3.4	75	150
Shiloh II, CA (2009-2010)	NA	NA	2.6	75	150
High Winds, CA (2003-2004)	NA	NA	2.51	90	162
Hatchet Ridge, CA (2011)	NA	NA	2.23	44	101
Lower West, CA (2012-2013)	NA	NA	2.17	7	14

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the number of bat passes per detector night. Fatality estimate given as the number of bat fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Dillon, CA (2008-2009)	NA	NA	2.17	45	45
Montezuma I, CA (2011)	NA	NA	1.9	16	36.8
High Winds, CA (2004-2005)	NA	NA	1.52	90	162
Alta Wind I, CA (2011-2012)	4.42[G]	6/26/09 -10/31/09	1.28	100	150
Lower West, CA (2014-2015)	NA	NA	1.13	7	14
Montezuma II, CA (2012-2013)	NA	NA	0.91	34	78.2
Montezuma I, CA (2012)	NA	NA	0.84	16	36.8
Diablo Winds, CA (2005-2007)	NA	NA	0.82	31	20.46
Alta X, CA (2015-2016)	NA	NA	0.8	48	137
Alta I, CA (2015-2016)	NA	NA	0.7	290	720
Alta X, CA (2014-2015)	NA	NA	0.42	48	137
Shiloh III, CA (2012-2013)	NA	NA	0.4	50	102.5
Alta I, CA (2013-2014)	NA	NA	0.36	290	720
Mustang Hills, CA (2016-2017)	NA	NA	0.33	100	300
Solano III, CA (2012-2013)	NA	NA	0.31	55	128
Alite, CA (2009-2010)	NA	NA	0.24	8	24
Pacific Wind, CA (2014-2015)	NA	NA	0.21	70	144
Cameron Ridge/Section 15, CA (2015-2016)	NA	NA	0.19	34	102
Pinyon Pines I & II, CA (2015-2016)	NA	NA	0.18	100	300
Alta VIII, CA (2014-2015)	NA	NA	0.17	100	300
Cameron Ridge/Section 15, CA (2014-2015)	NA	NA	0.15	34	102
Mustang Hills, CA (2012-2013)	NA	NA	0.1	50	150
Alta Wind II-V, CA (2011-2012)	0.78	6/26/09 -10/31/09	0.08	190	570
Pinyon Pines I & II, CA (2013-2014)	NA	NA	0.04	100	NA
Windstar, CA (2012-2013)	NA	NA	0	53	106
Lower West, CA (2016-2017)	NA	NA	0	7	14
Pacific Wind, CA (2015-2016)	NA	NA	0	70	144
Alta VIII, CA (2012-2013)	NA	NA	0	50	150
Rising Tree, CA (2017-2018)	NA	NA	0	60	198
Mustang Hills, CA (2014-2015)	NA	NA	0	100	300
Alta II-V, CA (2013-2014)	NA	NA	0	290	720
Alta II-V, CA (2015-2016)	NA	NA	0	290	720
Pacific Northwest					
Palouse Wind, WA (2012-2013)	NA	NA	4.23	58	104.4
Biglow Canyon, OR (Phase II; 2009-2010)	NA	NA	2.71	65	150
Nine Canyon, WA (2002-2003)	NA	NA	2.47	37	48.1
Stateline, OR/WA (2003)	NA	NA	2.29	454	299
Tucannon River, WA (2015)	NA	NA	2.22	116	267
Elkhorn, OR (2010)	NA	NA	2.14	61	101
White Creek, WA (2007-2011)	NA	NA	2.04	89	204.7
Biglow Canyon, OR (Phase I; 2008)	NA	NA	1.99	76	125.4
Leaning Juniper, OR (2006-2008)	NA	NA	1.98	67	100.5
Chopin, OR (2016-2017)	NA	NA	1.9	6	10

Appendix A1. Wind energy facilities in North America with comparable activity and fatality data for bats, separated by geographic region. Activity estimate given as the number of bat passes per detector night. Fatality estimate given as the number of bat fatalities per megawatt (MW) per year.

Wind Energy Facility	Bat Activity Estimate	Bat Activity Dates	Fatality Estimate	No. of Turbines	Total MW
Big Horn, WA (2006-2007)	NA	NA	1.9	133	199.5
Combine Hills, OR (Phase I; 2004-2005)	NA	NA	1.88	41	41
Linden Ranch, WA (2010-2011)	NA	NA	1.68	25	50
Pebble Springs, OR (2009-2010)	NA	NA	1.55	47	98.7
Hopkins Ridge, WA (2008)	NA	NA	1.39	87	156.6
Harvest Wind, WA (2010-2012)	NA	NA	1.27	43	98.9
Elkhorn, OR (2008)	NA	NA	1.26	61	101
Vansycle, OR (1999)	NA	NA	1.12	38	24.9
Klondike III (Phase I), OR (2007-2009)	NA	NA	1.11	125	223.6
Stateline, OR/WA (2001-2002)	NA	NA	1.09	454	299
Stateline, OR/WA (2006)	NA	NA	0.95	454	299
Tuolumne (Windy Point I), WA (2009-2010)	NA	NA	0.94	62	136.6
Klondike, OR (2002-2003)	NA	NA	0.77	16	24
Combine Hills, OR (2011)	NA	NA	0.73	104	104
Hopkins Ridge, WA (2006)	NA	NA	0.63	83	150
Biglow Canyon, OR (Phase I; 2009)	NA	NA	0.58	76	125.4
Biglow Canyon, OR (Phase II; 2010-2011)	NA	NA	0.57	65	150
Hay Canyon, OR (2009-2010)	NA	NA	0.53	48	100.8
Windy Flats, WA (2010-2011)	NA	NA	0.41	114	262.2
Klondike II, OR (2005-2006)	NA	NA	0.41	50	75
Vantage, WA (2010-2011)	NA	NA	0.4	60	90
Wild Horse, WA (2007)	NA	NA	0.39	127	229
Goodnoe, WA (2009-2010)	NA	NA	0.34	47	94
Marengo II, WA (2009-2010)	NA	NA	0.27	39	70.2
Biglow Canyon, OR (Phase III; 2010-2011)	NA	NA	0.22	76	174.8
Marengo I, WA (2009-2010)	NA	NA	0.17	78	140.4
Klondike IIIa (Phase II), OR (2008-2010)	NA	NA	0.14	51	76.5
Kittitas Valley, WA (2011-2012)	NA	NA	0.12	48	100.8

[A] = Activity rate based on data collected at various heights all other activity rates are from ground-based units only.

[B] = Activity rate was averaged across phases and/or years.

[C] = Activity rate calculated by WEST from data presented in referenced report.

[D] = Activity rate based on pre-construction monitoring; data for all other activity and fatality rates were collected concurrently.

[E] = Activity rate based on data collected from ground-based units excluding reference stations during the spring, summer and fall season's.

[F] = The overall activity rate of 28.5 is from reference stations located along forest edges which may be attractive to bats; the activity rate of 0.3 is from one unit placed on a nacelle.

[G] = Average of ground-based detectors at CPC Proper (Phase I) for late summer/fall period only.

Appendix A1 (*continued*). Wind energy facilities in North America with comparable fatality data for bats. Data from the following sources:

Project, Location	Activity Reference	Fatality Reference	Project, Location	Activity Reference	Fatality Reference
Three Waters, Minnesota		**This Study**			
Alite, CA (2009-2010)		Chatfield et al. 2010	Locust Ridge, PA (Phase II; 2009)		Arnett et al. 2011
Alta I, CA (2013-2014)		Chatfield et al. 2014	Locust Ridge, PA (Phase II; 2010)		Arnett et al. 2011
Alta I, CA (2015-2016)		Thompson et al. 2016a	Lower West, CA (2012-2013)		Levenstein and Bay 2013a
Alta II-V, CA (2013-2014)		Chatfield et al. 2014	Lower West, CA (2014-2015)		Levenstein and DiDonato 2015
Alta II-V, CA (2015-2016)		Thompson et al. 2016a	Lower West, CA (2016-2017)		WEST 2017b
Alta VIII, CA (2012-2013)		Chatfield and Bay 2014	Maple Ridge, NY (2006)		Jain et al. 2007
Alta VIII, CA (2014-2015)		Western EcoSystems Technology, Inc. (WEST) 2016c	Maple Ridge, NY (2007)		Jain et al. 2009a
Alta X, CA (2014-2015)		Chatfield et al. 2015	Maple Ridge, NY (2007-2008)		Jain et al. 2009b
Alta X, CA (2015-2016)		Thompson et al. 2016b	Maple Ridge, NY (2012)		Tidhar et al. 2013b
Alta Wind I, CA (2011-2012)	Solick et al. 2010	Chatfield et al. 2012	Marengo I, WA (2009-2010)		URS 2010b
Alta Wind II-V, CA (2011-2012)	Solick et al. 2010	Chatfield et al. 2012	Marengo II, WA (2009-2010)		URS 2010c
Barton I & II, IA (2010-2011)		Derby et al. 2011b	Mars Hill, ME (2007)		Stantec 2008a
Barton Chapel, TX (2009-2010)		WEST 2011	Mars Hill, ME (2008)		Stantec 2009a
Beech Ridge, WV (2012)		Tidhar et al. 2013a	Milford I, UT (2010-2011)		Stantec 2011b
Beech Ridge, WV (2013)		Young et al. 2014a	Milford I & II, UT (2011-2012)		Stantec 2012b
Big Blue, MN (2013)		Fagen Engineering 2014	Montezuma I, CA (2011)		ICF International 2012
Big Blue, MN (2014)		Fagen Engineering 2015	Montezuma I, CA (2012)		ICF International 2013
Big Horn, WA (2006-2007)		Kronner et al. 2008	Montezuma II, CA (2012-2013)		Harvey & Associates 2013
Big Smile, OK (2012-2013)		Derby et al. 2013b	Moraine II, MN (2009)		Derby et al. 2010f
Biglow Canyon, OR (Phase I; 2008)		Jeffrey et al. 2009b	Mount Storm, WV (Fall 2008)	Young et al. 2009c	Young et al. 2009c
Biglow Canyon, OR (Phase I; 2009)		Enk et al. 2010	Mount Storm, WV (2009)	Young et al. 2009a, 2010b	Young et al. 2009a, 2010b
Biglow Canyon, OR (Phase II; 2009-2010)		Enk et al. 2011b	Mount Storm, WV (2010)	Young et al. 2010a, 2011b	Young et al. 2010a, 2011b
Biglow Canyon, OR (Phase II; 2010-2011)		Enk et al. 2012b	Mount Storm, WV (2011)		Young et al. 2011a, 2012a
Biglow Canyon, OR (Phase III; 2010-2011)		Enk et al. 2012a	Mountaineer, WV (2003)		Kerns and Kerlinger 2004
Bingham Wind Project, ME (2017)		TRC 2017a	Munnsville, NY (2008)		Stantec 2009b

Appendix A1 (*continued*). Wind energy facilities in North America with comparable fatality data for bats. Data from the following sources:

Project, Location	Activity Reference	Fatality Reference	Project, Location	Activity Reference	Fatality Reference
Blue Sky Green Field, WI (2008; 2009)	Gruver 2008	Gruver et al. 2009	Mustang Hills, CA (2012-2013)		Chatfield and Bay 2014
Buffalo Gap I, TX (2006)		Tierney 2007	Mustang Hills, CA (2014-2015)		WEST 2016c
Buffalo Gap II, TX (2007-2008)		Tierney 2009	Mustang Hills, CA (2016-2017)		WEST 2018
Buffalo Mountain, TN (2000-2003)	Fiedler 2004	Nicholson et al. 2005	Nine Canyon, WA (2002-2003)		Erickson et al. 2003
Buffalo Mountain, TN (2005)		Fiedler et al. 2007	Noble Altona, NY (2010)		Jain et al. 2011a
Buffalo Ridge, MN (Phase I; 1999)		Johnson et al. 2000	Noble Bliss, NY (2008)		Jain et al.2009c
Buffalo Ridge, MN (Phase II; 1998)		Johnson et al. 2000	Noble Bliss, NY (2009)		Jain et al. 2010c
Buffalo Ridge, MN (Phase II; 1999)		Johnson et al. 2000	Noble Chateaugay, NY (2010)		Jain et al. 2011b
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Noble Clinton, NY (2008)	Reynolds 2010a	Jain et al. 2009d
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	Johnson et al. 2004	Johnson et al. 2004	Noble Clinton, NY (2009)	Reynolds 2010a	Jain et al. 2010a
Buffalo Ridge, MN (Phase III; 1999)		Johnson et al. 2000	Noble Ellenburg, NY (2008)		Jain et al. 2009e
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	Noble Ellenburg, NY (2009)	Reynolds 2010b	Jain et al. 2010b
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	Johnson et al. 2004	Johnson et al. 2004	Noble Wethersfield, NY (2010)		Jain et al. 2011c
Buffalo Ridge I, SD (2009-2010)		Derby et al. 2010d	NPPD Ainsworth, NE (2006)		Derby et al. 2007
Buffalo Ridge II, SD (2011-2012)		Derby et al. 2012a	Oakfield, ME (2017)		TRC 2018
Bull Hill, ME (2013)		Stantec Consulting (Stantec) 2014a	Odell, MN (2016-2017)		Chodachek and Gustafson 2018
Cameron Ridge/Section 15, CA (2014-2015)		WEST 2016b	Pacific Wind, CA (2014-2015)		WEST 2016a
Cameron Ridge/Section 15, CA (2015-2016)		Rintz and Thompson 2017	Pacific Wind, CA (2015-2016)		WEST 2017a
Casselman, PA (2008)		Arnett et al. 2009b	Palouse Wind, WA (2012-2013)		Stantec 2013a
Casselman, PA (2009)		Arnett et al. 2010	Pebble Springs, OR (2009-2010)		Gritski and Kronner 2010b
Casselman Curtailment, PA (2008)		Arnett et al. 2009a	Pinnacle, WV (2012)		Hein et al. 2013b
Cedar Ridge, WI (2009)	BHE Environ-mental 2008	BHE Environ-mental 2010	Pinyon Pines I & II, CA (2013-2014)		Chatfield and Russo 2014
Cedar Ridge, WI (2010)	BHE Environ-mental 2008	BHE Environ-mental 2011	Pinyon Pines I & II, CA (2015-2016)		Rintz and Starcevich 2016
Chopin, OR (2016-2017)		Hallingstad and Riser-Espinoza 2017	Pioneer Prairie I, IA (Phase II; 2011-2012)		Chodachek et al. 2012

Appendix A1 (*continued*). Wind energy facilities in North America with comparable fatality data for bats. Data from the following sources:

Project, Location	Activity Reference	Fatality Reference	Project, Location	Activity Reference	Fatality Reference
Cohocton/Dutch Hill, NY (2009)		Stantec 2010	Pioneer Prairie II, IA (2013)		Chodachek et al. 2014
Cohocton/Dutch Hill, NY (2013)		Stantec 2014b	Pleasant Valley, MN (2016-2017)		Tetra Tech 2017b
Cohocton/Dutch Hills, NY (2010)		Stantec 2011a	Prairie Rose, MN (2014)		Chodachek et al. 2015
Combine Hills, OR (Phase I; 2004-2005)		Young et al. 2006	PrairieWinds ND1 (Minot), ND (2010)		Derby et al. 2011d
Combine Hills, OR (2011)		Enz et al. 2012	PrairieWinds ND1 (Minot), ND (2011)		Derby et al. 2012d
Crescent Ridge, IL (2005-2006)		Kerlinger et al. 2007	PrairieWinds SD1, SD (2011-2012)		Derby et al. 2012c
Criterion, MD (2011)		Young et al. 2012b	PrairieWinds SD1, SD (2012-2013)		Derby et al. 2013a
Criterion, MD (2012)		Young et al. 2013	PrairieWinds SD1, SD (2013-2014)		Derby et al. 2014
Criterion, MD (2013)		Young et al. 2014b	Prince Wind Farm, ON (2006)		NRSI 2008
Crystal Lake II, IA (2009)		Derby et al. 2010b	Prince Wind Farm, ON (2007)		NRSI 2008
Diablo Winds, CA (2005-2007)		WEST 2006, 2008	Prince Wind Farm, ON (2008)		NRSI 2009
Dillon, CA (2008-2009)		Chatfield et al. 2009	Rail Splitter, IL (2012-2013)		Good et al. 2013b
Dry Lake I, AZ (2009-2010)	Thompson et al. 2011	Thompson et al. 2011	Record Hill, ME (2012)	Stantec 2008b	Stantec 2013b
Dry Lake II, AZ (2011-2012)	Thompson and Bay 2012	Thompson and Bay 2012	Record Hill, ME (2014)		Stantec 2015a
Elkhorn, OR (2008)		Jeffrey et a. 2009a	Record Hill, ME (2016)		Stantec 2017
Elkhorn, OR (2010)		Enk et al. 2011a	Red Hills, OK (2012-2013)		Derby et al. 2013c
Elm Creek, MN (2009-2010)		Derby et al. 2010e	Ripley, ON (2008)		Jacques Whitford 2009
Elm Creek II, MN (2011-2012)		Derby et al. 2012b	Rising Tree, CA (2017-2018)		Chatfield et al. 2018
Foote Creek Rim I, WY (1999)		Young et al. 2003	Rollins, ME (2012)		Stantec 2013c
Foote Creek Rim I, WY (2000)	Gruver 2002	Young et al. 2003	Rollins, ME (2014)		Stantec 2015b
Foote Creek Rim I, WY (2001-2002)	Gruver 2002	Young et al. 2003	Roth Rock, MD (2011)		Atwell, LLC 2012
Forward Energy Center, WI (2008-2010)	Watt and Drake 2011	Grodsky and Drake 2011	Rugby, ND (2010-2011)		Derby et al. 2011c
Fowler I, IN (2009)		Johnson et al. 2010a	Shiloh I, CA (2006-2009)		Kerlinger et al. 2009
Fowler I, II, III, IN (2010)		Good et al. 2011	Shiloh II, CA (2009-2010)		Kerlinger et al. 2010
Fowler I, II, III, IN (2011)		Good et al. 2012	Shiloh II, CA (2010-2011)		Kerlinger et al. 2013a
Fowler I, II, III, IN (2012)		Good et al. 2013a	Shiloh II, CA (2011-2012)		Kerlinger et al. 2013a
Fowler III, IN (2009)		Johnson et al. 2010b	Shiloh III, CA (2012-2013)		Kerlinger et al. 2013b
Fowler, IN (2014)		Good et al. 2015	Solano III, CA (2012-2013)		AECOM 2013

Appendix A1 (*continued*). Wind energy facilities in North America with comparable fatality data for bats. Data from the following sources:

Project, Location	Activity Reference	Fatality Reference	Project, Location	Activity Reference	Fatality Reference
Fowler, IN (2015)		Good et al. 2016	Spring Valley, NV (2012-2013)		WEST 2014
Fowler, IN (2016)		Good et al. 2017	Spruce Mountain Wind Project, ME (2014)		Tetra Tech 2015
Goodnoe, WA (2009-2010)		URS Corporation (URS) 2010a	Stateline, OR/WA (2001-2002)		Erickson et al. 2004
Grand Ridge I, IL (2009-2010)		Derby et al. 2010a	Stateline, OR/WA (2003)		Erickson et al. 2004
Groton, NH (2013)		Stantec and WEST 2014	Stateline, OR/WA (2006)		Erickson et al. 2007
Groton, NH (2014)		Stantec and WEST 2015a	Steel Winds I & II, NY (2013)		Stantec 2014c
Groton, NH (2015)		Stantec and WEST 2015b	Stetson II, ME (2014)		Stantec 2015c
Hancock, ME (2017)		TRC 2017b	Stetson Mountain I, ME (2009)	Stantec 2009c	Stantec 2009c
Harrow, ON (2010)		Natural Resources Solutions Inc. (NRSI) 2011	Stetson Mountain I, ME (2011)		Normandeau Associates 2011
Harvest Wind, WA (2010-2012)		Downes and Gritski 2012a	Stetson Mountain I, ME (2013)		Stantec 2014d
Hatchet Ridge, CA (2011)		Tetra Tech 2013	Stetson Mountain II, ME (2010)		Normandeau Associates 2010
Hatchet Ridge, CA (2012)		Tetra Tech 2013	Stetson Mountain II, ME (2012)		Stantec 2013d
Hatchet Ridge, CA (2012-2013)		Tetra Tech 2014	Summerview, AB (2005-2006)		Brown and Hamilton 2006
Hay Canyon, OR (2009-2010)		Gritski and Kronner 2010a	Summerview, AB (2006-2007)	Baerwald 2008	Baerwald 2008
High Sheldon, NY (2010)		Tidhar et al. 2012a	Top Crop I & II, IL (2012-2013)		Good et al. 2013c
High Sheldon, NY (2011)		Tidhar et al. 2012b	Top of Iowa, IA (2003)		Jain 2005
High Winds, CA (2003-2004)		Kerlinger et al. 2006	Top of Iowa, IA (2004)	Jain 2005	Jain 2005
High Winds, CA (2004-2005)		Kerlinger et al. 2006	Top of the World, WY (2010-2011)		Rintz and Bay 2012
Hopkins Ridge, WA (2006)		Young et al. 2007	Top of the World, WY (2011-2012)		Rintz and Bay 2013
Hopkins Ridge, WA (2008)		Young et al. 2009b	Top of the World, WY (2012-2013)		Rintz and Bay 2014
Howard, NY (2012)		Tidhar et al. 2013c	Tucannon River, WA (2015)		Hallingstad et al. 2016
Howard, NY (2013)		Lukins et al. 2014	Tuolumne (Windy Point I), WA (2009-2010)		Enz and Bay 2010
Judith Gap, MT (2006-2007)		TRC Environmental Corporation 2008	Vansycle, OR (1999)		Erickson et al. 2000
Judith Gap, MT (2009)		Poulton and Erickson 2010	Vantage, WA (2010-2011)		Ventus Environmental Solutions 2012
Kewaunee County, WI (1999-2001)		Howe et al. 2002	Waverly Wind, KS (2016-2017)		Tetra Tech 2017a
Kibby, ME (2011)		Stantec 2012a	Wessington Springs, SD (2009)		Derby et al. 2010c

Appendix A1 (*continued*). Wind energy facilities in North America with comparable fatality data for bats. Data from the following sources:

Project, Location	Activity Reference	Fatality Reference	Project, Location	Activity Reference	Fatality Reference
Kittitas Valley, WA (2011-2012)		Stantec Consulting Services 2012	Wessington Springs, SD (2010)		Derby et al. 2011a
Klondike, OR (2002-2003)		Johnson et al. 2003	White Creek, WA (2007-2011)		Downes and Gritski 2012b
Klondike II, OR (2005-2006)		Northwest Wildlife Consultants (NWC) and WEST 2007	Wild Horse, WA (2007)		Erickson et al. 2008
Klondike III (Phase I), OR (2007-2009)		Gritski et al. 2010	Windstar, CA (2012-2013)		Levenstein and Bay 2013b
Klondike IIIa (Phase II), OR (2008-2010)		Gritski et al. 2011	Windy Flats, WA (2010-2011)		Enz et al. 2011
Lakefield Wind, MN (2012)		Minnesota Public Utilities Commission 2012	Winnebago, IA (2009-2010)		Derby et al. 2010a
Leaning Juniper, OR (2006-2008)		Gritski et al. 2008	Wolfe Island, ON (July-December 2009)		Stantec Ltd. 2010
Lempster, NH (2009)		Tidhar et al. 2010	Wolfe Island, ON (July-December 2010)		Stantec Ltd. 2011
Lempster, NH (2010)		Tidhar et al. 2011	Wolfe Island, ON (July-December 2011)		Stantec Ltd. 2012
Linden Ranch, WA (2010-2011)		Enz and Bay 2011			

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Alite, CA (2009-2010)	0.24	shrub/scrub & grassland	Chatfield et al. 2010
Alta I, CA (2013-2014)	0.36	Grassland;Shrub Steppe	Chatfield et al. 2014
Alta I, CA (2015-2016)	0.7	Grassland;Shrub Steppe	Thompson et al. 2016a
Alta II-V, CA (2013-2014)	0	Grassland;Shrub Steppe	Chatfield et al. 2014
Alta II-V, CA (2015-2016)	0	Grassland;Shrub Steppe	Thompson et al. 2016a
Alta VIII, CA (2012-2013)	0	grassland and riparian	Chatfield and Bay 2014
Alta VIII, CA (2014-2015)	0.17	Desert Creosote;Grassland;Joshua Tree	Western EcoSystems Technology, Inc. (WEST) 2016c
Alta Wind I, CA (2011-2012)	1.28	woodland, grassland, shrubland	Chatfield et al. 2015
Alta Wind II-V, CA (2011-2012)	0.08	desert scrub	Thompson et al. 2016b
Alta X, CA (2014-2015)	0.42	Forest/Woodlot;Shrub Steppe	Chatfield et al. 2012
Alta X, CA (2015-2016)	0.8	Shrub Steppe	Chatfield et al. 2012
Barton Chapel, TX (2009-2010)	3.06	agriculture/forest	WEST 2011
Barton I & II, IA (2010-2011)	1.85	agriculture	Derby et al. 2011b
Beech Ridge, WV (2012)	2.03	forest	Tidhar et al. 2013a
Beech Ridge, WV (2013)	0.58	forest	Young et al. 2014a
Big Blue, MN (2013)	2.04	agriculture	Fagen Engineering 2014
Big Blue, MN (2014)	1.43	agriculture	Fagen Engineering 2015
Big Horn, WA (2006-2007)	1.9	agriculture/grassland	Kronner et al. 2008
Big Smile, OK (2012-2013)	2.9	grassland, agriculture	Derby et al. 2013b
Biglow Canyon, OR (Phase I; 2008)	1.99	agriculture/grassland	Jeffrey et al. 2009b
Biglow Canyon, OR (Phase I; 2009)	0.58	agriculture/grassland	Enk et al. 2010
Biglow Canyon, OR (Phase II; 2009-2010)	2.71	agriculture	Enk et al. 2011b
Biglow Canyon, OR (Phase II; 2010-2011)	0.57	grassland/shrub-steppe, agriculture	Enk et al. 2012b
Biglow Canyon, OR (Phase III; 2010-2011)	0.22	grassland/shrub-steppe, agriculture	Enk et al. 2012a
Bingham Wind Project, ME (2017)	0.23	Bermuda Grass/Mixed Grasses;Clover;Road and Pad	TRC 2017a
Blue Sky Green Field, WI (2008; 2009)	24.57	agriculture	Gruver et al. 2009
Buffalo Gap I, TX (2006)	0.1	grassland	Tierney 2007
Buffalo Gap II, TX (2007-2008)	0.14	forest	Tierney 2009
Buffalo Mountain, TN (2000-2003)	31.54	forest	Nicholson et al. 2005

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Buffalo Mountain, TN (2005)	39.7	forest	Fiedler et al. 2007
Buffalo Ridge I, SD (2009-2010)	0.16	agriculture/grassland	Derby et al. 2010d
Buffalo Ridge II, SD (2011-2012)	2.81	agriculture, grassland	Derby et al. 2012a
Buffalo Ridge, MN (Phase I; 1999)	0.74	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1998)	2.16	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 1999)	2.59	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	4.35	agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	1.64	agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 1999)	2.72	agriculture	Johnson et al. 2000
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	3.71	agriculture	Johnson et al. 2004
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	1.81	agriculture	Johnson et al. 2004
Bull Hill, ME (2013)	1.62	forest	Stantec Consulting, Inc. (Stantec) 2014a
Cameron Ridge/Section 15, CA (2014-2015)	0.15	Shrub Steppe	WEST 2016b
Cameron Ridge/Section 15, CA (2015-2016)	0.19	Shrub Steppe	Rintz and Thompson 2017
Casselman Curtailment, PA (2008)	4.4	forest	Arnett et al. 2009a
Casselman, PA (2008)	12.61	forest	Arnett et al. 2009b
Casselman, PA (2009)	8.6	forest, pasture, grassland	Arnett et al. 2010
Cedar Ridge, WI (2009)	30.61	agriculture	BHE Environmental 2010
Cedar Ridge, WI (2010)	24.12	agriculture	BHE Environmental 2011
Chopin, OR (2016-2017)	1.9	Agriculture	Hallingstad and Riser-Espinoza 2017
Cohocton/Dutch Hill, NY (2009)	8.62	agriculture/forest	Stantec 2010
Cohocton/Dutch Hill, NY (2013)	1.37	Agriculture;Forest/Woodlot	Stantec 2014b
Cohocton/Dutch Hills, NY (2010)	10.32	agriculture/forest	Stantec 2011a
Combine Hills, OR (2011)	0.73	grassland/shrub-steppe, agriculture	Young et al. 2006
Combine Hills, OR (Phase I; 2004-2005)	1.88	agriculture/grassland	Enz et al. 2012
Crescent Ridge, IL (2005-2006)	3.27	agriculture	Kerlinger et al. 2007
Criterion, MD (2011)	15.61	forest, agriculture	Young et al. 2012b

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Criterion, MD (2012)	7.62	forest, agriculture	Young et al. 2013
Criterion, MD (2013)	5.32	forest, agriculture	Young et al. 2014b
Crystal Lake II, IA (2009)	7.42	agriculture	Derby et al. 2010b
Diablo Winds, CA (2005-2007)	0.82		WEST 2006, 2008
Dillon, CA (2008-2009)	2.17	desert	Chatfield et al. 2009
Dry Lake I, AZ (2009-2010)	3.43	desert grassland/forested	Thompson et al. 2011
Dry Lake II, AZ (2011-2012)	1.66	desert grassland/forested	Thompson and Bay 2012
Elkhorn, OR (2008)	1.26	shrub/scrub & agriculture	Jeffrey et a. 2009a
Elkhorn, OR (2010)	2.14	shrub/scrub & agriculture	Enk et al. 2011a
Elm Creek II, MN (2011-2012)	2.81	agriculture, grassland	Derby et al. 2010e
Elm Creek, MN (2009-2010)	1.49	agriculture	Derby et al. 2012b
Foote Creek Rim I, WY (1999)	3.97	grassland	Young et al. 2003
Foote Creek Rim I, WY (2000)	1.05	grassland	Young et al. 2003
Foote Creek Rim I, WY (2001-2002)	1.57	grassland	Young et al. 2003
Forward Energy Center, WI (2008-2010)	18.17	agriculture	Grodsky and Drake 2011
Fowler I, II, III, IN (2010)	18.96	agriculture	Good et al. 2011
Fowler I, II, III, IN (2011)	20.19	agriculture	Good et al. 2012
Fowler I, II, III, IN (2012)	2.96	agriculture	Good et al. 2013a
Fowler I, IN (2009)	1.84	agriculture	Johnson et al. 2010a
Fowler III, IN (2009)	1.84	agriculture	Johnson et al. 2010b
Fowler, IN (2014)	3.84	Agriculture;Developed	Good et al. 2015
Fowler, IN (2015)	4.86	Agriculture;Developed	Good et al. 2016
Fowler, IN (2016)	4.54	Agriculture;Developed	Good et al. 2017
Goodnoe, WA (2009-2010)	0.34	grassland and shrub-steppe	URS Corporation (URS) 2010a
Grand Ridge I, IL (2009-2010)	2.1	agriculture	Derby et al. 2010a
Groton, NH (2013)	1.31	Forest/Woodlot	Stantec and WEST 2014
Groton, NH (2014)	1.63	Forest/Woodlot	Stantec and WEST 2015a
Groton, NH (2015)	1.74	Forest/Woodlot	Stantec and WEST 2015b
Hancock, ME (2017)	0.3	Clover;Gravel;Road and Pad	TRC 2017b
Harrow, Ont (2010)	11.13	agriculture	Natural Resource Solutions Inc. (NRSI) 2011
Harvest Wind, WA (2010-2012)	1.27	grassland/shrub-steppe	Downes and Gritski 2012a
Hatchet Ridge, CA (2011)	2.23	Forest/Woodlot	Tetra Tech 2013
Hatchet Ridge, CA (2012-2013)	5.22	Forest/Woodlot	Tetra Tech 2013

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Hatchet Ridge, CA (2012)	4.2		Tetra Tech 2014
Hay Canyon, OR (2009-2010)	0.53	agriculture	Gritski and Kronner 2010a
High Sheldon, NY (2010)	2.33	agriculture	Tidhar et al. 2012a
High Sheldon, NY (2011)	1.78	agriculture	Tidhar et al. 2012b
High Winds, CA (2003-2004)	2.51	agriculture/grassland	Kerlinger et al. 2006
High Winds, CA (2004-2005)	1.52	agriculture/grassland	Kerlinger et al. 2006
Hopkins Ridge, WA (2006)	0.63	agriculture/grassland	Young et al. 2007
Hopkins Ridge, WA (2008)	1.39	agriculture/grassland	Young et al. 2009b
Howard, NY (2012)	10	Agriculture;Forest/Woodlot;Pasture	Tidhar et al. 2013c
Howard, NY (2013)	2.13	Agriculture;Forest/Woodlot;Pasture	Lukins et al. 2014
Judith Gap, MT (2006-2007)	8.93	agriculture/grassland	TRC Environmental Corporation 2008
Judith Gap, MT (2009)	3.2	agriculture/grassland	Poulton and Erickson 2010
Kewaunee County, WI (1999-2001)	6.45	agriculture	Howe et al. 2002
Kibby, ME (2011)	0.12	forest; commercial forest	Stantec 2012a
Kittitas Valley, WA (2011-2012)	0.12	sagebrush-steppe, grassland	Stantec Consulting Services 2012
Klondike II, OR (2005-2006)	0.41	agriculture/grassland	Northwest Wildlife Consultants (NWC) and WEST 2007
Klondike III (Phase I), OR (2007-2009)	1.11	agriculture/grassland	Gritski et al. 2010
Klondike IIIa (Phase II), OR (2008-2010)	0.14	grassland/shrub-steppe and agriculture	Gritski et al. 2011
Klondike, OR (2002-2003)	0.77	agriculture/grassland	Johnson et al. 2003
Lakefield Wind, MN (2012)	19.87	agriculture	Minnesota Public Utilities Commission 2012
Leaning Juniper, OR (2006-2008)	1.98	agriculture	Gritski et al. 2008
Lempster, NH (2009)	3.11	grasslands/forest/rocky embankments	Tidhar et al. 2010
Lempster, NH (2010)	3.57	grasslands/forest/rocky embankments	Tidhar et al. 2011
Linden Ranch, WA (2010-2011)	1.68	grassland/shrub-steppe, agriculture	Enz and Bay 2011
Locust Ridge, PA (Phase II; 2009)	14.11	grassland	Arnett et al. 2011
Locust Ridge, PA (Phase II; 2010)	14.38	grassland	Arnett et al. 2011
Lower West, CA (2012-2013)	2.17	Joshua Tree;Shrub Steppe	Levenstein and Bay 2013a
Lower West, CA (2014-2015)	1.13	Joshua Tree;Shrub Steppe	Levenstein and DiDonato 2015
Lower West, CA (2016-2017)	0	Joshua Tree;Shrub Steppe	WEST 2017b
Maple Ridge, NY (2006)	11.21	agriculture/forested	Jain et al. 2007

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Maple Ridge, NY (2007-2008)	6.49	agriculture/forested	Jain et al. 2009a
Maple Ridge, NY (2007)	4.96	agriculture/forested	Jain et al. 2009b
Maple Ridge, NY (2012)	7.3	agriculture/forested	Tidhar et al. 2013b
Marengo I, WA (2009-2010)	0.17	agriculture	URS 2010b
Marengo II, WA (2009-2010)	0.27	agriculture	URS 2010c
Mars Hill, ME (2007)	2.91	forest	Stantec 2008a
Mars Hill, ME (2008)	0.45	forest	Stantec 2009a
Milford I & II, UT (2011-2012)	1.67	desert shrub	Stantec 2011b
Milford I, UT (2010-2011)	2.05	desert shrub	Stantec 2012b
Montezuma I, CA (2011)	1.9	agriculture and grasslands	ICF International 2012
Montezuma I, CA (2012)	0.84	agriculture and grasslands	ICF International 2013
Montezuma II, CA (2012-2013)	0.91	agriculture	Harvey & Associates 2013
Moraine II, MN (2009)	2.42	agriculture/grassland	Derby et al. 2010f
Mount Storm, WV (2009)	17.53	forest	Young et al. 2009c
Mount Storm, WV (2010)	15.18	forest	Young et al. 2009a, 2010b
Mount Storm, WV (2011)	7.43	forest	Young et al. 2010a, 2011b
Mount Storm, WV (Fall 2008)	6.62	forest	Young et al. 2011a, 2012a
Mountaineer, WV (2003)	31.69	forest	Kerns and Kerlinger 2004
Munnsville, NY (2008)	1.93	agriculture/forest	Stantec 2009b
Mustang Hills, CA (2012-2013)	0.1	Grasslands and Riparian	Chatfield and Bay 2014
Mustang Hills, CA (2014-2015)	0	Desert Creosote;Grassland;Joshua Tree	WEST 2016c
Mustang Hills, CA (2016-2017)	0.33	Joshua Tree;Shrub Steppe	WEST 2018
Nine Canyon, WA (2002-2003)	2.47	agriculture/grassland	Erickson et al. 2003
Noble Altona, NY (2010)	4.34	forest	Jain et al. 2011a
Noble Bliss, NY (2008)	7.8	agriculture/forest	Jain et al. 2009c
Noble Bliss, NY (2009)	3.85	agriculture/forest	Jain et al. 2010c
Noble Chateaugay, NY (2010)	2.44	agriculture	Jain et al. 2011b
Noble Clinton, NY (2008)	3.14	agriculture/forest	Jain et al. 2009d
Noble Clinton, NY (2009)	4.5	agriculture/forest	Jain et al. 2010a
Noble Ellenburg, NY (2008)	3.46	agriculture/forest	Jain et al. 2009e
Noble Ellenburg, NY (2009)	3.91	agriculture/forest	Jain et al. 2010b
Noble Wethersfield, NY (2010)	16.3	agriculture	Jain et al. 2011c
NPPD Ainsworth, NE (2006)	1.16	agriculture/grassland	Derby et al. 2007
Oakfield, ME (2017)	0.51	Bermuda Grass/Mixed Grasses;Clover;Gravel	TRC 2018
Odell, MN (2016-2017)	6.74	Agriculture	Chodachek and Gustafson 2018

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Pacific Wind, CA (2014-2015)	0.21	Desert Creosote;Joshua Tree;Pinyon Pine/ Juniper	WEST 2016a
Pacific Wind, CA (2015-2016)	0	Desert Creosote;Joshua Tree;Pinyon Pine/ Juniper	WEST 2017a
Palouse Wind, WA (2012-2013)	4.23	agriculture and grasslands	Stantec 2013a
Pebble Springs, OR (2009-2010)	1.55	grassland	Gritski and Kronner 2010b
Pinnacle, WV (2012)	40.2	forest	Hein et al. 2013b
Pinyon Pines I & II, CA (2013-2014)	0.04	NA	Chatfield and Russo 2014
Pinyon Pines I & II, CA (2015-2016)	0.18	Desert Creosote;Joshua Tree	Rintz and Starcevich 2016
Pioneer Prairie I, IA (Phase II; 2011-2012)	4.43	agriculture, grassland	Chodachek et al. 2012
Pioneer Prairie II, IA (2013)	3.83	agriculture	Chodachek et al. 2014
Pleasant Valley, MN (2016-2017)	1.8	Agriculture;Grassland;Wetlands	Tetra Tech 2017b
Prairie Rose, MN (2014)	0.41	Agriculture;Grassland	Chodachek et al. 2015
PrairieWinds ND1 (Minot), ND (2010)	2.13	agriculture	Derby et al. 2011d
PrairieWinds ND1 (Minot), ND (2011)	1.39	agriculture, grassland	Derby et al. 2012d
PrairieWinds SD1, SD (2011-2012)	1.23	grassland	Derby et al. 2012c
PrairieWinds SD1, SD (2012-2013)	1.05	grassland	Derby et al. 2013a
PrairieWinds SD1, SD (2013-2014)	0.52	grassland	Derby et al. 2014
Prince Wind Farm, ON (2006)	1.27	forest	NRSI 2008
Prince Wind Farm, ON (2007)	1.03	forest	NRSI 2008
Prince Wind Farm, ON (2008)	2.39	forest	NRSI 2009
Rail Splitter, IL (2012-2013)	11.21	agriculture	Good et al. 2013b
Record Hill, ME (2012)	2.96	forest	Stantec 2013b
Record Hill, ME (2014)	0.55	forest	Stantec 2015a
Record Hill, ME (2016)	1.25	Forest/Woodlot;Rocky Outcrop	Stantec 2017
Red Hills, OK (2012-2013)	0.11	grassland	Derby et al. 2013c
Ripley, ON (2008)	4.67	agriculture	Jacques Whitford 2009
Rising Tree, CA (2017-2018)	0	Desert Creosote;Joshua Tree;Shrub Steppe	Chatfield et al. 2018
Rollins, ME (2012)	0.18	forest	Stantec 2013c
Rollins, ME (2014)	0.33	Forest/Woodlot;Gravel	Stantec 2015b
Roth Rock, MD (2011)	6.24	Forest/Woodlot;Rocky Outcrop	Atwell, LLC 2012
Rugby, ND (2010-2011)	1.6	agriculture	Derby et al. 2011c

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Shiloh I, CA (2006-2009)	3.92	agriculture/grassland	Kerlinger et al. 2009
Shiloh II, CA (2009-2010)	2.6	agriculture	Kerlinger et al. 2010
Shiloh II, CA (2010-2011)	3.8	agriculture	Kerlinger et al. 2013a
Shiloh II, CA (2011-2012)	3.4	agriculture	Kerlinger et al. 2013a
Shiloh III, CA (2012-2013)	0.4	NA	Kerlinger et al. 2013b
Solano III, CA (2012-2013)	0.31	NA	AECOM 2013
Spring Valley, NV (2012-2013)	3.73	Grassland;Shrub Steppe	WEST 2014
Spruce Mountain Wind Project, ME (2014)	0.31	Forest/Woodlot;Gravel;Rocky Outcrop	Tetra Tech 2015
Stateline, OR/WA (2001-2002)	1.09	agriculture/grassland	Erickson et al. 2004
Stateline, OR/WA (2003)	2.29	agriculture/grassland	Erickson et al. 2004
Stateline, OR/WA (2006)	0.95	agriculture/grassland	Erickson et al. 2007
Steel Winds I & II, NY (2013)	6.14	Deciduous Shrub;Grassland;Gravel;Other	Stantec 2014c
Stetson II, ME (2014)	0.83	Bermuda Grass/Mixed Grasses;Forest/Woodlot	Stantec 2015c
Stetson Mountain I, ME (2009)	1.4	forest	Stantec 2009c
Stetson Mountain I, ME (2011)	0.28	forest	Normandeau Associates 2011
Stetson Mountain I, ME (2013)	0.18	forest	Stantec 2014d
Stetson Mountain II, ME (2010)	1.65	forest	Normandeau Associates 2010
Stetson Mountain II, ME (2012)	2.27	forest	Stantec 2013d
Summerview, AB (2005-2006)	10.27	agriculture	Brown and Hamilton 2006
Summerview, AB (2006-2007)	11.42	agriculture/grassland	Baerwald 2008
Top Crop I & II (2012-2013)	12.55	agriculture	Good et al. 2013c
Top of Iowa, IA (2003)	7.16	agriculture	Jain 2005
Top of Iowa, IA (2004)	10.27	agriculture	Jain 2005
Top of the World, WY (2010-2011)	2.74	Grassland; Other	Rintz and Bay 2012
Top of the World, WY (2011-2012)	2.43	Grassland; Other	Rintz and Bay 2013
Top of the World, WY (2012-2013)	2.34	Grassland Other	Rintz and Bay 2014
Tucannon River, WA (2015)	2.22	Cropland; Developed; Grassland; Shrub Steppe; Winter Wheat	Hallingstad et al. 2016
Tuolumne (Windy Point I), WA (2009-2010)	0.94	grassland/shrub-steppe, agriculture and forest	Enz and Bay 2010
Vansycle, OR (1999)	1.12	agriculture/grassland	Erickson et al. 2000

Appendix A2. Fatality estimates for North American wind energy facilities.

Project	Bat Fatalities (bats/megawatt/year)	Predominant Habitat Type	Citation
Vantage, WA (2010-2011)	0.4	Shrub-steppe, grassland	Ventus Environmental Solutions 2012
Waverly Wind, KS (2016-2017)	8.2	Agriculture; Grassland	Tetra Tech 2017a
Wessington Springs, SD (2009)	1.48	grassland	Derby et al. 2010c
Wessington Springs, SD (2010)	0.41	grassland	Derby et al. 2011a
White Creek, WA (2007-2011)	2.04	grassland/shrub-steppe, agriculture	Downes and Gritski 2012b
Wild Horse, WA (2007)	0.39	grassland	Erickson et al. 2008
Windstar, CA (2012-2013)	0	Grassland; Pinyon Pine/ Juniper	Levenstein and Bay 2013b
Windy Flats, WA (2010-2011)	0.41	grassland/shrub-steppe, agriculture	Enz et al. 2011
Winnebago, IA (2009-2010)	4.54	agriculture/grassland	Derby et al. 2010a
Wolfe Island, ON (July-December 2009)	6.42	grassland	Stantec Consulting Ltd. (Stantec Ltd.) 2010
Wolfe Island, ON (July-December 2010)	9.5	grassland	Stantec Ltd. 2011
Wolfe Island, ON (July-December 2011)	2.49	grassland	Stantec Ltd. 2012

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Alite, CA (2009-2010)	8	24	80	8	200 m x 200 m	1 year	weekly (spring, fall), bi-monthly (summer, winter)
Alta I, CA (2013-2014)	290	720	80	NA	120 m radius	1 year	monthly; twice per month
Alta I, CA (2015-2016)	290	720	80	NA	120 m radius	1 year	monthly; twice per month
Alta II-V, CA (2013-2014)	290	720	80	NA	120 m radius	1 year	monthly; twice per month
Alta II-V, CA (2015-2016)	290	720	80	NA	120 m radius	1 year	monthly; twice per month
Alta VIII, CA (2012-2013)	50	150	90	12 plots (equivalent to 15 turbines)	240 x 240 m	1 year	bi-weekly
Alta VIII, CA (2014-2015)	100	300	90	NA	240 m x 240 m	NA	twice per month
Alta Wind I, CA (2011-2012)	100	150	80	25	120-m radius circle	12.5 months	every two weeks
Alta Wind II-V, CA (2011-2012)	190	570	80	41	120-m radius circle	14.5 months	every two weeks
Alta X, CA (2014-2015)	48	137	100	NA	240 m x 240 m	1 year	twice per month
Alta X, CA (2015-2016)	48	137	100	NA	240 m x 240 m	1 year	twice per month
Barton Chapel, TX (2009-2010)	60	120	78	30	200 m x 200 m	1 year	10 turbines weekly, 20 monthly
Barton I & II, IA (2010-2011)	80	160	100	35 (9 turbines were dropped in June 2010 due to landowner issues) 26 turbines were searched for the remainder of the study	200 m x 200 m	1 year	weekly (spring, fall; migratory turbines), monthly (summer, winter; non-migratory turbines)
Beech Ridge, WV (2012)	67	100.5	80	67	40 m radius	7 months	every two days
Beech Ridge, WV (2013)	67	100.5	80	67	40 m radius	7.5 months	every two days

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Big Blue, MN (2013)	18	36	78 or 90 (according to Gamesa website)	18	200m diameter	NA	weekly, monthly (Nov and Dec)
Big Blue, MN (2014)	18	36	78 or 90 (according to Gamesa website)	18	200m diameter	NA	weekly, monthly (Nov and Dec)
Big Horn, WA (2006-2007)	133	199.5	80	133	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Big Smile, OK (2012-2013)	66	132	78	17 (plus one met tower)	100 x 100	1 year	weekly (spring, summer, fall), monthly (winter)
Biglow Canyon, OR (Phase I; 2008)	76	125.4	80	50	110 m x 110 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Biglow Canyon, OR (Phase I; 2009)	76	125.4	80	50	110 m x 110 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Biglow Canyon, OR (Phase II; 2009-2010)	65	150	80	50	250 m x 250 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Biglow Canyon, OR (Phase II; 2010-2011)	65	150	80	50	252 m x 252 m	1 year	bi-weekly(spring, fall), monthly (summer, winter)
Biglow Canyon, OR (Phase III; 2010-2011)	76	174.8	80	50	252 m x 252 m	1 year	bi-weekly(spring, fall), monthly (summer, winter)
Bingham Wind Project, ME (2017)	56	185	94	NA	within 80m; within 140 m	7 months	twice per week
Blue Sky Green Field, WI (2008; 2009)	88	145	80	30	160 m x 160 m	fall, spring	daily(10 turbines), weekly (20 turbines)
Buffalo Gap I, TX (2006)	67	134	78	21	215 m x 215 m	10 months	every 3 weeks
Buffalo Gap II, TX (2007-2008)	155	233	80	36	215 m x 215 m	14 months	every 21 days
Buffalo Mountain, TN (2000-2003)	3	1.98	65	3	50-m radius	3 years	bi-weekly, weekly, bi-monthly
Buffalo Mountain, TN (2005)	18	28.98	V47 = 65; V80 = 78	18	50-m radius	1 year	bi-weekly, weekly, bi-monthly, and 2 to 5 day intervals

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Buffalo Ridge I, SD (2009-2010)	24	50.4	79	24	200 m x 200 m	1 year	weekly (migratory), monthly (non-migratory)
Buffalo Ridge II, SD (2011-2012)	105	210	78	65 (60 road and pad, 5 turbine plots)	100 x 100m	1 year	weekly (spring, summer, fall), monthly (winter)
Buffalo Ridge, MN (Phase I; 1999)	73	25	36	21	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase II; 1998)	143	107.25	50	40	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase II; 1999)	143	107.25	50	40	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	143	107.25	50	83	60 m x 60 m	summer, fall	bi-monthly
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	143	107.25	50	103	60 m x 60 m	summer, fall	bi-monthly
Buffalo Ridge, MN (Phase III; 1999)	138	103.5	50	30	126 m x 126 m	1 year	bi-monthly (spring, summer, and fall)
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	138	103.5	50	83	60 m x 60 m	summer, fall	bi-monthly
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	138	103.5	50	103	60 m x 60 m	summer, fall	bi-monthly
Bull Hill, ME (2013)	19	34	95	19	80 m radius	6 months	weekly (spring), daily and weekly (fall)
Cameron Ridge/Section 15, CA (2014-2015)	34	102	80	NA	62.5m radius	1 year	weekly
Cameron Ridge/Section 15, CA (2015-2016)	34	102	80	NA	125m radius	NA	weekly
Casselman Curtailment, PA (2008)	23	35.4	80	12 experimental; 10 control	126 m x 120 m	2.5 months	daily
Casselman, PA (2008)	23	34.5	80	10	126 m x 120 m	7 months	daily
Casselman, PA (2009)	23	34.5	80	10	126 m x 120 m	7.5 months	daily searches

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Cedar Ridge, WI (2009)	41	67.6	80	20	160 m x 160 m	spring, summer, fall	daily, every 4 days; late fall searched every 3 days
Cedar Ridge, WI (2010)	41	68	80	20	160 m x 160 m	1 year	Five turbines were surveyed daily, 15 turbines surveyed every 4 days in rotating groups each day. All 20 surveyed every three days during late fall
Chopin, OR (2016-2017)	6	10	NA	NA	270m x 270m	1 year	monthly
Cohocton/Dutch Hill, NY (2009)	50	125	80	17	130 m x 130 m	spring, summer, fall	daily (5 turbines), weekly (12 turbines)
Cohocton/Dutch Hill, NY (2013)	50	125	80	NA	120m x 120m	4 months	weekly
Cohocton/Dutch Hills, NY (2010)	50	125	80	17	120 m x 120 m	spring, summer, fall	daily, weekly
Combine Hills, OR (2011)	104	104	53	52 (plus 1 MET tower)	180 m x 180 m	1 year	bi-weekly(spring, fall), monthly (summer, winter)
Combine Hills, OR (Phase I; 2004-2005)	41	41	53	41	90-m radius	1 year	monthly
Crescent Ridge, IL (2005-2006)	33	49.5	80	33	70-m radius	1 year	weekly (fall, spring)
Criterion, MD (2011)	28	70	80	28	40-50m radius	7.3 months	daily
Criterion, MD (2012)	28	70	80	14	40-50m radius	7.5 months	weekly
Criterion, MD (2013)	28	70	80	14	40-50m radius	7.5 months	weekly
Crystal Lake II, IA (2009)	80	200	80	16 turbines through week 6, and then 15 for duration of study	100 m x 100 m	spring, summer, fall	3 times per week for 26 weeks
Diablo Winds, CA (2005-2007)	31	20.46	50 and 55	31	75 m x 75 m	2 years	monthly
Dillon, CA (2008-2009)	45	45	69	15	200 m x 200 m	1 year	weekly, bi-monthly in winter

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Dry Lake I, AZ (2009-2010)	30	63	78	15	160 m x 160 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Dry Lake II, AZ (2011-2012)	31	65	78	31: 5 (full plot), 26 (road & pad)	160 m x 160 m	1 year	twice weekly (spring, summer, fall), weekly (winter)
Elkhorn, OR (2008)	61	101	80	61	220 m x 220 m	1 year	monthly
Elkhorn, OR (2010)	61	101	80	31	220 m x 220 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Elm Creek II, MN (2011-2012)	62	148.8	80	30	200 x 200m (2 random migration search areas 100 x 100m)	1 year	20 searched every 28 days, 10 turbines every 7 days during migration)
Elm Creek, MN (2009-2010)	67	100	80	29	200 m x 200 m	1 year	weekly, monthly
Foote Creek Rim I, WY (1999)	69	41.4	40	69	126 m x 126 m	1 year	monthly
Foote Creek Rim I, WY (2000)	69	41.4	40	69	126 m x 126 m	1 year	monthly
Foote Creek Rim I, WY (2001-2002)	69	41.4	40	69	126 m x 126 m	1 year	monthly
Forward Energy Center, WI (2008-2010)	86	129	80	29	160 m x 160 m	2 years	11 turbines daily, 9 every 3 days, 9 every 5 days
Fowler I, II, III, IN (2010)	355	600	Vestas = 80, Clipper = 80, GE = 80	36 turbines, 100 road and pads	80 m x 80 m for turbines ; 40-m radius for roads and pads	spring, fall	daily, weekly
Fowler I, II, III, IN (2011)	355	600	Vestas = 80, Clipper = 80, GE = 80	177 road and pads (spring), 9 turbines & 168 roads and pads (fall)	turbines (80 m circular plot), roads and pads (out to 80 m)	spring, fall	daily, weekly
Fowler I, II, III, IN (2012)	355	600	Vestas = 80, Clipper = 80, GE = 80	118 roads and pads	roads and pads (out to 80 m)	2.5 months	weekly

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Fowler I, IN (2009)	162	301	78 (Vestas), 80 (Clipper)	25	160 m x 160 m	spring, summer, fall	weekly, bi-weekly
Fowler III, IN (2009)	60	99	78	12	160 m x 160 m	10 weeks	weekly, bi-weekly
Fowler, IN (2014)	355	600	80	NA	road/pad; 80m radius	3 months	twice per week
Fowler, IN (2015)	355	600	80	NA	road/pad; 80m radius	3 months	twice per week
Fowler, IN (2016)	420	NA	80	NA	road/pad; 80m radius	3 months	weekly
Goodnoe, WA (2009-2010)	47	94	80	24	180 m x 180 m	1 year	14 days during migration periods, 28 days during non-migration periods
Grand Ridge I, IL (2009-2010)	66	99	80	30	160 m x 160 m	1 year	weekly, monthly
Groton, NH (2013)	24	48	78	NA	road/pad; 60m radius	7 months	weekly
Groton, NH (2014)	24	48	78	NA	road/pad; 60m radius	6 months	weekly
Groton, NH (2015)	24	48	78	NA	road/pad; 60m radius	6 months	weekly
Hancock, ME (2017)	17	51	80	NA	within 80 m; within 140 m	7 months	twice per week
Harrow, ON (2010)	24 (four 6-turb facilities)	39.6	NA	12 in July, 24 Aug-Oct	50-m radius from turbine base	4 months	twice-weekly
Harvest Wind, WA (2010-2012)	43	98.9	80	32	180 m x 180 m & 240 m x 240 m	2 years	twice a week, weekly and monthly
Hatchet Ridge, CA (2011)	44	101	80	NA	127m x 127m (bi-monthly), 190m x 190m (monthly)	NA	monthly;twice per month
Hatchet Ridge, CA (2012-2013)	44	NA	80	NA	127m x 127m	1 year	twice per month
Hatchet Ridge, CA (2012)	44	101	80	NA	127m x 127m (bi-monthly), 190m x 190m (monthly)	NA	monthly;twice per month

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Hay Canyon, OR (2009-2010)	48	100.8	79	20	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
High Sheldon, NY (2010)	75	112.5	80	25	115 m x 115 m	7 months	daily (8 turbines), weekly (17 turbines)
High Sheldon, NY (2011)	75	112.5	80	25	115 m x 115 m	7 months	daily (8 turbines), weekly (17 turbines)
High Winds, CA (2003-2004)	90	162	60	90	75-m radius	1 year	bi-monthly
High Winds, CA (2004-2005)	90	162	60	90	75-m radius	1 year	bi-monthly
Hopkins Ridge, WA (2006)	83	150	67	41	180 m x 180 m	1 year	monthly, weekly (subset of 22 turbines spring and fall migration)
Hopkins Ridge, WA (2008)	87	156.6	67	41-43	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Howard, NY (2012)	27	54	78.5	NA	120m x 120m	7 months	daily;weekly
Howard, NY (2013)	27	54	78.5	NA	120m x 120m	6 months	daily;weekly
Judith Gap, MT (2006-2007)	90	135	80	20	190 m x 190 m	7 months	monthly
Judith Gap, MT (2009)	90	135	80	30	100 m x 100 m	5 months	bi-monthly
Kewaunee County, WI (1999-2001)	31	20.46	65	31	60 m x 60 m	2 years	bi-weekly (spring, summer), daily (spring, fall migration), weekly (fall, winter)
Kibby, ME (2011)	44	132	124	22 turbines	75-m diameter circular plots	22 weeks	avg 5-day
Kittitas Valley, WA (2011-2012)	48	100.8	80	48	100 m x 102 m	1 year	bi-weekly from Aug 15 - Oct 31 and March 16 - May 15; every 4 weeks from Nov 1 - March 15 and May 16 - Aug 14
Klondike II, OR (2005-2006)	50	75	80	25	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (summer, winter)

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Klondike III (Phase I), OR (2007-2009)	125	223.6	GE = 80; Siemens= 80, Mitsubishi = 80	46	240 m x 240 m (1.5MW) 252 m x 252 m (2.3MW)	2 year	bi-monthly (spring, fall migration), monthly (summer, winter)
Klondike IIIa (Phase II), OR (2008-2010)	51	76.5	GE = 80	34	240 m x 240 m	2 years	bi-monthly (spring, fall), monthly (summer, winter)
Klondike, OR (2002-2003)	16	24	80	16	140 m x 140 m	1 year	monthly
Lakefield Wind, MN (2012)	137	205.5	80	26	100 m x 100 m	7.5 months	3 times per week
Leaning Juniper, OR (2006-2008)	67	100.5	80	17	240 m x 240 m	2 years	bi-monthly (spring, fall), monthly (winter, summer)
Lempster, NH (2009)	12	24	78	4	120 m x 130 m	6 months	daily
Lempster, NH (2010)	12	24	78	12	120 m x 130 m	6 months	weekly
Linden Ranch, WA (2010-2011)	25	50	80	25	110 m x 110 m	1 year	bi-weekly(spring, fall), monthly (summer, winter)
Locust Ridge, PA (Phase II; 2009)	51	102	80	15	120m x 126m	6.5 months	daily
Locust Ridge, PA (Phase II; 2010)	51	102	80	15	120m x 126m	6.5 months	daily
Lower West, CA (2012-2013)	7	14	110.5	NA	120m radius	NA	twice per month
Lower West, CA (2014-2015)	7	14	110.5	NA	120m radius	NA	twice per month
Lower West, CA (2016-2017)	7	14	110.5	NA	120m radius	1 year	twice per week
Maple Ridge, NY (2006)	120	198	80	50	130 m x 120 m	5 months	daily (10 turbines), every 3 days (10 turbines), weekly (30 turbines)
Maple Ridge, NY (2007-2008)	195	321.75	80	64	130 m x 120 m	7 months	weekly
Maple Ridge, NY (2007)	195	321.75	80	64	130 m x 120 m	7 months	weekly
Maple Ridge, NY (2012)	195	321.75	80	105 (5 turbines, 100 roads/pads)	100 m x 100 m	3 months	weekly

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Marengo I, WA (2009-2010)	78	140.4	67	39	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Marengo II, WA (2009-2010)	39	70.2	67	20	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Mars Hill, ME (2007)	28	42	80.5	28	76-m diameter, extended plot 238-m diameter	spring, summer, fall	daily (2 random turbines), weekly (all turbines): extended plot searched once per season
Mars Hill, ME (2008)	28	42	80.5	28	76-m diameter, extended plot 238-m diameter	spring, summer, fall	weekly: extended plot searched once per season
Milford I & II, UT (2011-2012)	107	160.5 (58.5 I, 102 II)	80	43	120x120	NA	every 10.5 days
Milford I, UT (2010-2011)	58	145	80	24	120x120	NA	weekly
Montezuma I, CA (2011)	16	36.8	80	16	105 m radius	1 year	Weekly and bi-Weekly
Montezuma I, CA (2012)	16	36.8	80	16	105 m radius	1 year	Weekly and bi-Weekly
Montezuma II, CA (2012-2013)	34	78.2	80	17	105 m radius	1 year	Weekly
Moraine II, MN (2009)	33	49.5	82.5	30	200 m x 200 m	1 year	weekly (migratory), monthly (non-migratory)
Mount Storm, WV (2009)	132	264	78	44	varied	4.5 months	weekly (28 turbines), daily (16 turbines)
Mount Storm, WV (2010)	132	264	78	24	20 to 60 m from turbine	6 months	daily
Mount Storm, WV (2011)	132	264	78	24	varied	6 months	daily
Mount Storm, WV (Fall 2008)	82	164	78	27	varied	3 months	weekly (18 turbines), daily (9 turbines)
Mountaineer, WV (2003)	44	66	80	44	60-m radius	7 months	weekly, monthly
Munnsville, NY (2008)	23	34.5	69.5	12	120 m x 120 m	spring, summer, fall	weekly

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Mustang Hills, CA (2012-2013)	50	150	90	13 plots (equivalent to 15 turbines)	240 x 240 m	1 year	bi-weekly
Mustang Hills, CA (2014-2015)	100	300	90	NA	240m x 240m	NA	twice per month
Mustang Hills, CA (2016-2017)	100	300	100	NA	240m x 240m	1 year	twice per month
Nine Canyon, WA (2002-2003)	37	48.1	60	37	90-m radius	1 year	bi-monthly (spring, summer, fall), monthly (winter)
Noble Altona, NY (2010)	65	97.5	80	22	120 m x 120 m	spring, summer, fall	daily, weekly
Noble Bliss, NY (2008)	67	100	80	23	120 m x 120 m	spring, summer, fall	daily (8 turbines), 3-day (8 turbines), weekly (7 turbines)
Noble Bliss, NY (2009)	67	100	80	23	120 m x 120 m	spring, summer, fall	weekly, 8 turbines searched daily from July 1 to August 15
Noble Chateaugay, NY (2010)	71	106.5	80	24	120 m x 120 m	spring, summer, fall	weekly
Noble Clinton, NY (2008)	67	100	80	23	120 m x 120 m	spring, summer, fall	daily (8 turbines), 3-day (8 turbines), weekly (7 turbines)
Noble Clinton, NY (2009)	67	100	80	23	120 m x 120 m	spring, summer, fall	daily (8 turbines), weekly (15 turbines), all turbines weekly from July 1 to August 15
Noble Ellenburg, NY (2008)	54	80	80	18	120 m x 120 m	spring, summer, fall	daily (6 turbines), 3-day (6 turbines), weekly (6 turbines)
Noble Ellenburg, NY (2009)	54	80	80	18	120 m x 120 m	spring, summer, fall	daily (6 turbines), weekly (12 turbines), all turbines weekly from July 1 to August 15
Noble Wethersfield, NY (2010)	84	126	80	28	120 m x 120 m	spring, summer, fall	weekly

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
NPPD Ainsworth, NE (2006)	36	20.5	70	36	220 m x 220 m	spring, summer, fall	bi-monthly
Oakfield, ME (2017)	48	148	94	NA	within 80 m; within 140 m	7 months	other
Odell, MN (2016-2017)	100	200	NA	NA	120m x 120m	1 year	monthly;weekly
Pacific Wind, CA (2014-2015)	70	144	78.5	NA	126m radius	NA	weekly
Pacific Wind, CA (2015-2016)	70	144	78.5	NA	63m radius	NA	weekly
Palouse Wind, WA (2012-2013)	58	104.4	80, 90, or 105 M (according to the Vestas website)	19	120m x 120m	1 year	Montly (Winter) and Weekly (Spring-Fall)
Pebble Springs, OR (2009-2010)	47	98.7	79	20	180 m x 180 m	1 year	bi-monthly (spring, fall), monthly (winter, summer)
Pinnacle, WV (2012)	23	55.2	80	11	126 m x 120m	9 months	weekly
Pinyon Pines I & II, CA (2013-2014)	100	NA	90	25 plots (aprox 31 turbines)	240x240 m	NA	bi-weekly
Pinyon Pines I & II, CA (2015-2016)	100	300	90	NA	240m x 240m	NA	twice per month
Pioneer Prairie I, IA (Phase II; 2011-2012)	62	102.3	80	62 (57 road/pad) 5 full search plots	80 x 80m	1 year	weekly (spring and fall), every two weeks (summer), monthly (winter)
Pioneer Prairie II, IA (2013)	62	102.3	80	62	80x80 m (5 turbines), road and pad within 100 m of turbine (57 turbines)	NA	weekly
Pleasant Valley, MN (2016-2017)	100	200	95	NA	160m x 160m	NA	weekly
Prairie Rose, MN (2014)	119	200	80	NA	100m x 100m (spring); road/pad (fall)	1 year	weekly

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
PrairieWinds ND1 (Minot), ND (2010)	80	115.5	89	35	minimum of 100 m x 100 m	3 seasons	bi-monthly
PrairieWinds ND1 (Minot), ND (2011)	80	115.5	80	35	minimum 100 x 100m	3 season	twice monthly
PrairieWinds SD1, SD (2011-2012)	108	162	80	50	200 x 200m	1 year	twice monthly (spring, summer, fall), monthly (winter)
PrairieWinds SD1, SD (2012-2013)	108	162	80	50	200 x 200m	1 year	bi-weekly
PrairieWinds SD1, SD (2013-2014)	108	162	80	45	200 x 200m	1 year	twice monthly (spring, summer, fall), monthly (winter)
Prince Wind Farm, ON (2006)	126	189	80	38	63-m radius	4 months	daily, weekly
Prince Wind Farm, ON (2007)	126	189	80	38 turbines from January 1st - July 8th, 126 turbines from July 9th-October 31st	63- to 45-m radius	10 months	daily, weekly
Prince Wind Farm, ON (2008)	126	189	80	126	45m radius	6.5 months	daily, 3x/week, 2x/week
Rail Splitter, IL (2012-2013)	67	100.5	80	34	60 m radius	1 year	weekly (spring, summer, and fall) and bi-weekly (winter)
Record Hill, ME (2012)	22	50.6	80	22	126.5x126.5	5 months	three times every two weeks
Record Hill, ME (2014)	22	50.6	80	10	varied due to steep terrain and heavily vegetated areas	4.5 months	daily for 5 days a week
Record Hill, ME (2016)	22	51	80	NA	42.5m radius	7 months	other
Red Hills, OK (2012-2013)	82	123	80	20 (plus one met tower)	100 x 100	1 year	weekly (spring, summer, fall), monthly (winter)
Ripley, ON (2008)	38	76	64	38	80 m x 80 m	spring, fall	twice weekly for odd turbines; weekly for even turbines.

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Rising Tree, CA (2017-2018)	60	198	84	NA	280m x 280m	1 year	twice per month
Rollins, ME (2012)	40	60	80	20	varied; turbine laydown area and gravel access roads out to 60m	6 months	weekly
Rollins, ME (2014)	40	60	NA	NA	60m radius	6 months	weekly
Roth Rock, MD (2011)	20	50	80	NA	80m x 80m	3 months	daily
Rugby, ND (2010-2011)	71	149	78	32	200 m x 200 m	1 year	weekly (spring, fall; migratory turbines), monthly (non-migratory turbines)
Shiloh I, CA (2006-2009)	100	150	65	100	105-m radius	3 years	weekly
Shiloh II, CA (2009-2010)	75	150	80	25	100m radius	1 year	weekly
Shiloh II, CA (2010-2011)	75	150	80	25	100 m radius	1 year	weekly
Shiloh II, CA (2011-2012)	75	150	80	25	100 m radius	1 year	weekly
Shiloh III, CA (2012-2013)	50	102.5	78.5	25	100 m radius	NA	weekly
Solano III, CA (2012-2013)	55	128	80	19	100 m radius	NA	bi-Weekly
Spring Valley, NV (2012-2013)	66	152	80	NA	126m x 126m	1 year, 2 months	daily;twice per month
Spruce Mountain Wind Project, ME (2014)	10	20	78	NA	road/pad; 100m radius	NA	twice per week
Stateline, OR/WA (2001-2002)	454	299	50	124	minimum 126 m x 126 m	17 months	bi-weekly, monthly
Stateline, OR/WA (2003)	454	299	50	153	minimum 126 m x 126 m	1 year	bi-weekly, monthly
Stateline, OR/WA (2006)	454	299	50	39	variable turbine strings	1 year	bi-weekly
Steel Winds I & II, NY (2013)	14	35	80	NA	120m x 120m	5 months	twice per week

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Stetson II, ME (2014)	17	26	NA	NA	60m radius	6 months	weekly
Stetson Mountain I, ME (2009)	38	57	80	19	76-m diameter	27 weeks (spring, summer, fall)	weekly
Stetson Mountain I, ME (2011)	38	57	80	19	79.45x79.45m	6 months	weekly
Stetson Mountain I, ME (2013)	38	57	80	19	76 m diameter	6 months	weekly
Stetson Mountain II, ME (2010)	17	25.5	80	17	74.5x74.5m	6 months	weekly (3 turbines twice a week)
Stetson Mountain II, ME (2012)	17	25.5	80	17	laydown area and road up to 60m	6 months	weekly
Summerview, AB (2005-2006)	39	70.2	67	39	140 m x 140 m	1 year	weekly, bi-weekly (May to July, September)
Summerview, AB (2006-2007)	39	70.2	65	39	52-m radius; 2 spiral transects 7 m apart	summer, fall (2 years)	daily (10 turbines), weekly (29 turbines)
Top Crop I & II (2012-2013)	68 (phase I) 132 (phase (II)	300 (102 (phase I) 198 (phase II))	65 (phase I) 80 (phase II)	100	61 m radius	1 year	weekly (spring, summer, and fall) and bi-weekly (winter)
Top of Iowa, IA (2003)	89	80	71.6	26	76 m x 76 m	spring, summer, fall	once every 2 to 3 days
Top of Iowa, IA (2004)	89	80	71.6	26	76 m x 76 m	spring, summer, fall	once every 2 to 3 days
Top of the World, WY (2010-2011)	110	200	80	NA	160m x 160m	1 year	twice per month;weekly
Top of the World, WY (2011-2012)	110	200	80	NA	160m x 160m	1 year	twice per month;weekly
Top of the World, WY (2012-2013)	110	200	80	NA	160m x 160m	1 year	twice per month;weekly
Tucannon River, WA (2015)	116	267	80	NA	134m radius	1 year	

Appendix A3. All post-construction monitoring studies, project characteristics, and select study methodology.

Project Name	Total # of Turbines	Total Megawatts	Tower size (meters)	Number turbines searched	Plot Size	Length of Study	Survey Frequency
Tuolumne (Windy Point I), WA (2009-2010)	62	136.6	80	21	180 m x 180 m	1 year	monthly throughout the year, a sub-set of 10 turbines were also searched weekly during the spring, summer, and fall
Vansycle, OR (1999)	38	24.9	50	38	126 m x 126 m	1 year	monthly
Vantage, WA (2010-2011)	60	90	80	30	240 m x 240 m	1 year	monthly, a subset of 10 searched weekly during migration
Waverly Wind, KS (2016-2017)	95	199	93	NA	160m x 160m; road/pad	1 year	twice per month;weekly
Wessington Springs, SD (2009)	34	51	80	20	200 m x 200 m	spring, summer, fall	bi-monthly
Wessington Springs, SD (2010)	34	51	80	20	200 m x 200 m	8 months	bi-weekly (spring, summer, fall)
White Creek, WA (2007-2011)	89	204.7	80	89	180 m x 180 m & 240 m x 240 m	4 years	twice a week, weekly and monthly
Wild Horse, WA (2007)	127	229	67	64	110 m from two turbines in plot	1 year	monthly, weekly (fall, spring migration at 16 turbines)
Windstar, CA (2012-2013)	53	106	107;110.5	NA	120m radius	NA	monthly;twice per month
Windy Flats, WA (2010-2011)	114	262.2	80	36 (plus 1 MET tower)	180 m x 180 m (120m at MET tower)	1 year	monthly (spring, summer, fall, and winter), weekly (spring and fall migration)
Winnebago, IA (2009-2010)	10	20	78	10	200 m x 200 m	1 year	weekly (migratory), monthly (non-migratory)
Wolfe Island, ON (July-December 2009)	86	197.8	80	86	60-m radius	summer, fall	43 twice weekly, 43 weekly
Wolfe Island, ON (July-December 2010)	86	197.8	80	86	50-m radius	6 months	43 twice weekly, 43 weekly
Wolfe Island, ON (July-December 2011)	86	197.8	80	86	50m radius	6 months	43 twice weekly, 43 weekly

Appendix A3 (*continued*). All post-construction monitoring studies, project characteristics, and select study methodology. Data from the following sources:

Project, Location	Reference	Project, Location	Reference
Alite, CA (2009-2010)	Chatfield et al. 2010	Locust Ridge, PA (Phase II; 2009)	Arnett et al. 2011
Alta I, CA (2013-2014)	Chatfield et al. 2014	Locust Ridge, PA (Phase II; 2010)	Arnett et al. 2011
Alta I, CA (2015-2016)	Thompson et al. 2016a	Lower West, CA (2012-2013)	Levenstein and Bay 2013a
Alta II-V, CA (2013-2014)	Chatfield et al. 2014	Lower West, CA (2014-2015)	Levenstein and DiDonato 2015
Alta II-V, CA (2015-2016)	Thompson et al. 2016a	Lower West, CA (2016-2017)	WEST 2017b
Alta VIII, CA (2012-2013)	Chatfield and Bay 2014	Maple Ridge, NY (2006)	Jain et al. 2007
Alta VIII, CA (2014-2015)	Western EcoSystems Technology, Inc. (WEST) 2016c	Maple Ridge, NY (2007-2008)	Jain et al. 2009a
Alta Wind I, CA (2011-2012)	Chatfield et al. 2015	Maple Ridge, NY (2007)	Jain et al. 2009b
Alta Wind II-V, CA (2011-2012)	Thompson et al. 2016b	Maple Ridge, NY (2012)	Tidhar et al. 2013b
Alta X, CA (2014-2015)	Chatfield et al. 2012	Marengo I, WA (2009-2010)	URS 2010b
Alta X, CA (2015-2016)	Chatfield et al. 2012	Marengo II, WA (2009-2010)	URS 2010c
Barton Chapel, TX (2009-2010)	Derby et al. 2011b	Mars Hill, ME (2007)	Stantec 2008a
Barton I & II, IA (2010-2011)	WEST 2011	Mars Hill, ME (2008)	Stantec 2009a
Beech Ridge, WV (2012)	Tidhar et al. 2013a	Milford I & II, UT (2011-2012)	Stantec 2011b
Beech Ridge, WV (2013)	Young et al. 2014a	Milford I, UT (2010-2011)	Stantec 2012b
Big Blue, MN (2013)	Fagen Engineering 2014	Montezuma I, CA (2011)	ICF International 2012
Big Blue, MN (2014)	Fagen Engineering 2015	Montezuma I, CA (2012)	ICF International 2013
Big Horn, WA (2006-2007)	Kronner et al. 2008	Montezuma II, CA (2012-2013)	Harvey & Associates 2013
Big Smile, OK (2012-2013)	Derby et al. 2013b	Moraine II, MN (2009)	Derby et al. 2010f
Biglow Canyon, OR (Phase I; 2008)	Jeffrey et al. 2009b	Mount Storm, WV (2009)	Young et al. 2009c
Biglow Canyon, OR (Phase I; 2009)	Enk et al. 2010	Mount Storm, WV (2010)	Young et al. 2009a, 2010b
Biglow Canyon, OR (Phase II; 2009-2010)	Enk et al. 2011b	Mount Storm, WV (2011)	Young et al. 2010a, 2011b
Biglow Canyon, OR (Phase II; 2010-2011)	Enk et al. 2012b	Mount Storm, WV (Fall 2008)	Young et al. 2011a, 2012a
Biglow Canyon, OR (Phase III; 2010-2011)	Enk et al. 2012a	Mountaineer, WV (2003)	Kerns and Kerlinger 2004
Bingham Wind Project, ME (2017)	TRC 2017a	Munnsville, NY (2008)	Stantec 2009b
Blue Sky Green Field, WI (2008; 2009)	Gruver et al. 2009	Mustang Hills, CA (2012-2013)	Chatfield and Bay 2014
Buffalo Gap I, TX (2006)	Tierney 2007	Mustang Hills, CA (2014-2015)	WEST 2016c
Buffalo Gap II, TX (2007-2008)	Tierney 2009	Mustang Hills, CA (2016-2017)	WEST 2018
Buffalo Mountain, TN (2000-2003)	Nicholson et al. 2005	Nine Canyon, WA (2002-2003)	Erickson et al. 2003
Buffalo Mountain, TN (2005)	Fiedler et al. 2007	Noble Altona, NY (2010)	Jain et al. 2011a
Buffalo Ridge I, SD (2009-2010)	Johnson et al. 2000	Noble Bliss, NY (2008)	Jain et al.2009c
Buffalo Ridge II, SD (2011-2012)	Johnson et al. 2000	Noble Bliss, NY (2009)	Jain et al. 2010c
Buffalo Ridge, MN (Phase I; 1999)	Johnson et al. 2000	Noble Chateaugay, NY (2010)	Jain et al. 2011b
Buffalo Ridge, MN (Phase II; 1998)	Johnson et al. 2004	Noble Clinton, NY (2008)	Jain et al. 2009d

Appendix A3 (*continued*). All post-construction monitoring studies, project characteristics, and select study methodology. Data from the following sources:

Project, Location	Reference	Project, Location	Reference
Buffalo Ridge, MN (Phase II; 1999)	Johnson et al. 2004	Noble Clinton, NY (2009)	Jain et al. 2010a
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	Johnson et al. 2000	Noble Ellenburg, NY (2008)	Jain et al. 2009e
Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	Johnson et al. 2004	Noble Ellenburg, NY (2009)	Jain et al. 2010b
Buffalo Ridge, MN (Phase III; 1999)	Johnson et al. 2004	Noble Wethersfield, NY (2010)	Jain et al. 2011c
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	Derby et al. 2010d	NPPD Ainsworth, NE (2006)	Derby et al. 2007
Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	Derby et al. 2012a	Oakfield, ME (2017)	TRC 2018
Bull Hill, ME (2013)	Stantec Consulting (Stantec) 2014a	Odell, MN (2016-2017)	Chodachek and Gustafson 2018
Cameron Ridge/Section 15, CA (2014-2015)	WEST 2016b	Pacific Wind, CA (2014-2015)	WEST 2016a
Cameron Ridge/Section 15, CA (2015-2016)	Rintz and Thompson 2017	Pacific Wind, CA (2015-2016)	WEST 2017a
Casselman Curtailment, PA (2008)	Arnett et al. 2009b	Palouse Wind, WA (2012-2013)	Stantec 2013a
Casselman, PA (2008)	Arnett et al. 2010	Pebble Springs, OR (2009-2010)	Gritski and Kronner 2010b
Casselman, PA (2009)	Arnett et al. 2009a	Pinnacle, WV (2012)	Hein et al. 2013b
Cedar Ridge, WI (2009)	BHE Environ-mental 2010	Pinyon Pines I & II, CA (2013-2014)	Chatfield and Russo 2014
Cedar Ridge, WI (2010)	BHE Environ-mental 2011	Pinyon Pines I & II, CA (2015-2016)	Rintz and Starcevich 2016
Chopin, OR (2016-2017)	Hallingstad and Riser-Espinoza 2017	Pioneer Prairie I, IA (Phase II; 2011-2012)	Chodachek et al. 2012
Cohocton/Dutch Hill, NY (2009)	Stantec 2010	Pioneer Prairie II, IA (2013)	Chodachek et al. 2014
Cohocton/Dutch Hill, NY (2013)	Stantec 2014b	Pleasant Valley, MN (2016-2017)	Tetra Tech 2017b
Cohocton/Dutch Hills, NY (2010)	Stantec 2011a	Prairie Rose, MN (2014)	Chodachek et al. 2015
Combine Hills, OR (2011)	Young et al. 2006	PrairieWinds ND1 (Minot), ND (2010)	Derby et al. 2011d
Combine Hills, OR (Phase I; 2004-2005)	Enz et al. 2012	PrairieWinds ND1 (Minot), ND (2011)	Derby et al. 2012d
Crescent Ridge, IL (2005-2006)	Kerlinger et al. 2007	PrairieWinds SD1, SD (2011-2012)	Derby et al. 2012c
Criterion, MD (2011)	Young et al. 2012b	PrairieWinds SD1, SD (2012-2013)	Derby et al. 2013a
Criterion, MD (2012)	Young et al. 2013	PrairieWinds SD1, SD (2013-2014)	Derby et al. 2014
Criterion, MD (2013)	Young et al. 2014b	Prince Wind Farm, ON (2006)	NRSI 2008
Crystal Lake II, IA (2009)	Derby et al. 2010b	Prince Wind Farm, ON (2007)	NRSI 2008
Diablo Winds, CA (2005-2007)	WEST 2006, 2008	Prince Wind Farm, ON (2008)	NRSI 2009
Dillon, CA (2008-2009)	Chatfield et al. 2009	Rail Splitter, IL (2012-2013)	Good et al. 2013b
Dry Lake I, AZ (2009-2010)	Thompson et al. 2011	Record Hill, ME (2012)	Stantec 2013b
Dry Lake II, AZ (2011-2012)	Thompson and Bay 2012	Record Hill, ME (2014)	Stantec 2015a
Elkhorn, OR (2008)	Jeffrey et a. 2009a	Record Hill, ME (2016)	Stantec 2017
Elkhorn, OR (2010)	Enk et al. 2011a	Red Hills, OK (2012-2013)	Derby et al. 2013c
Elm Creek II, MN (2011-2012)	Derby et al. 2010e	Ripley, ON (2008)	Jacques Whitford 2009
Elm Creek, MN (2009-2010)	Derby et al. 2012b	Rising Tree, CA (2017-2018)	Chatfield et al. 2018
Foote Creek Rim I, WY (1999)	Young et al. 2003	Rollins, ME (2012)	Stantec 2013c

Appendix A3 (*continued*). All post-construction monitoring studies, project characteristics, and select study methodology. Data from the following sources:

Project, Location	Reference	Project, Location	Reference
Foote Creek Rim I, WY (2000)	Young et al. 2003	Rollins, ME (2014)	Stantec 2015b
Foote Creek Rim I, WY (2001-2002)	Young et al. 2003	Roth Rock, MD (2011)	Atwell, LLC 2012
Forward Energy Center, WI (2008-2010)	Grodsky and Drake 2011	Rugby, ND (2010-2011)	Derby et al. 2011c
Fowler I, II, III, IN (2010)	Johnson et al. 2010a	Shiloh I, CA (2006-2009)	Kerlinger et al. 2009
Fowler I, II, III, IN (2011)	Good et al. 2011	Shiloh II, CA (2009-2010)	Kerlinger et al. 2010
Fowler I, II, III, IN (2012)	Good et al. 2012	Shiloh II, CA (2010-2011)	Kerlinger et al. 2013a
Fowler I, IN (2009)	Good et al. 2013a	Shiloh II, CA (2011-2012)	Kerlinger et al. 2013a
Fowler III, IN (2009)	Johnson et al. 2010b	Shiloh III, CA (2012-2013)	Kerlinger et al. 2013b
Fowler, IN (2014)	Good et al. 2015	Solano III, CA (2012-2013)	AECOM 2013
Fowler, IN (2015)	Good et al. 2016	Spring Valley, NV (2012-2013)	WEST 2014
Fowler, IN (2016)	Good et al. 2017	Spruce Mountain Wind Project, ME (2014)	Tetra Tech 2015
Goodnoe, WA (2009-2010)	URS Corporation (URS) 2010a	Stateline, OR/WA (2001-2002)	Erickson et al. 2004
Grand Ridge I, IL (2009-2010)	Derby et al. 2010a	Stateline, OR/WA (2003)	Erickson et al. 2004
Groton, NH (2013)	Stantec and WEST 2014	Stateline, OR/WA (2006)	Erickson et al. 2007
Groton, NH (2014)	Stantec and WEST 2015a	Steel Winds I & II, NY (2013)	Stantec 2014c
Groton, NH (2015)	Stantec and WEST 2015b	Stetson II, ME (2014)	Stantec 2015c
Hancock, ME (2017)	TRC 2017b	Stetson Mountain I, ME (2009)	Stantec 2009c
Harrow, ON (2010)	Natural Resources Solutions Inc. (NRSI) 2011	Stetson Mountain I, ME (2011)	Normandeau Associates 2011
Harvest Wind, WA (2010-2012)	Downes and Gritski 2012a	Stetson Mountain I, ME (2013)	Stantec 2014d
Hatchet Ridge, CA (2011)	Tetra Tech 2013	Stetson Mountain II, ME (2010)	Normandeau Associates 2010
Hatchet Ridge, CA (2012-2013)	Tetra Tech 2013	Stetson Mountain II, ME (2012)	Stantec 2013d
Hatchet Ridge, CA (2012)	Tetra Tech 2014	Summerview, AB (2005-2006)	Brown and Hamilton 2006
Hay Canyon, OR (2009-2010)	Gritski and Kronner 2010a	Summerview, AB (2006-2007)	Baerwald 2008
High Sheldon, NY (2010)	Tidhar et al. 2012a	Top Crop I & II (2012-2013)	Good et al. 2013c
High Sheldon, NY (2011)	Tidhar et al. 2012b	Top of Iowa, IA (2003)	Jain 2005
High Winds, CA (2003-2004)	Kerlinger et al. 2006	Top of Iowa, IA (2004)	Jain 2005
High Winds, CA (2004-2005)	Kerlinger et al. 2006	Top of the World, WY (2010-2011)	Rintz and Bay 2012
Hopkins Ridge, WA (2006)	Young et al. 2007	Top of the World, WY (2011-2012)	Rintz and Bay 2013
Hopkins Ridge, WA (2008)	Young et al. 2009b	Top of the World, WY (2012-2013)	Rintz and Bay 2014
Howard, NY (2012)	Tidhar et al. 2013c	Tucannon River, WA (2015)	Hallingstad et al. 2016
Howard, NY (2013)	Lukins et al. 2014	Tuolumne (Windy Point I), WA (2009-2010)	Enz and Bay 2010
Judith Gap, MT (2006-2007)	TRC Environmental Corporation 2008	Vansycle, OR (1999)	Erickson et al. 2000
Judith Gap, MT (2009)	Poulton and Erickson 2010	Vantage, WA (2010-2011)	Ventus Environmental Solutions 2012
Kewaunee County, WI (1999-2001)	Howe et al. 2002	Waverly Wind, KS (2016-2017)	Tetra Tech 2017a
Kibby, ME (2011)	Stantec 2012a	Wessington Springs, SD (2009)	Derby et al. 2010c
Kittitas Valley, WA (2011-2012)	Stantec Consulting Services 2012	Wessington Springs, SD (2010)	Derby et al. 2011a

Appendix A3 (*continued*). All post-construction monitoring studies, project characteristics, and select study methodology. Data from the following sources:

Project, Location	Reference	Project, Location	Reference
Klondike II, OR (2005-2006)	Johnson et al. 2003	White Creek, WA (2007-2011)	Downes and Gritski 2012b
Klondike III (Phase I), OR (2007-2009)	Northwest Wildlife Consultants (NWC) and WEST 2007	Wild Horse, WA (2007)	Erickson et al. 2008
Klondike IIIa (Phase II), OR (2008-2010)	Gritski et al. 2010	Windstar, CA (2012-2013)	Levenstein and Bay 2013b
Klondike, OR (2002-2003)	Gritski et al. 2011	Windy Flats, WA (2010-2011)	Enz et al. 2011
Lakefield Wind, MN (2012)	Minnesota Public Utilities Commission 2012	Winnebago, IA (2009-2010)	Derby et al. 2010a
Leaning Juniper, OR (2006-2008)	Gritski et al. 2008	Wolfe Island, ON (July-December 2009)	Stantec Ltd. 2010
Lempster, NH (2009)	Tidhar et al. 2010	Wolfe Island, ON (July-December 2010)	Stantec Ltd. 2011
Lempster, NH (2010)	Tidhar et al. 2011	Wolfe Island, ON (July-December 2011)	Stantec Ltd. 2012
Linden Ranch, WA (2010-2011)	Enz and Bay 2011		

Summer Bat Survey Report for NLEB 2017

THREE WATERS WIND ENERGY PROJECT SUMMER BAT SURVEY REPORT
JACKSON COUNTY, MINNESOTA
DICKINSON AND OSCEOLA COUNTIES, IOWA

June 17 – 20, 2017

Prepared for:

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REPORT REFERENCE

Sichmeller, T. and B. Hyzy. 2017. Three Waters Wind Energy Project Summer Bat Survey Report Jackson County, Minnesota and Dickinson and Osceola Counties, Iowa. June 17 – 20, 2017. Prepared for Three Waters Wind Farm, LLC, Boulder, CO. Prepared by Western EcoSystems Technology, Inc. (WEST), Fort Collins, Colorado.

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INTRODUCTION

Three Waters Wind Farm, LLC (Three Waters) is proposing to develop the Three Waters Wind Energy Project (Project) in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa (Figure 1). In 2017, Three Waters contracted Western EcoSystems Technology, Inc. (WEST) to conduct presence/probable absence surveys for the federally threatened northern long-eared bat (*M. septentrionalis*; NLEB) within the Project. The main objectives of the summer bat surveys were to: 1) to determine the summer presence/probable absence of the NLEB in areas potentially affected by construction activities, 2) determine sites where follow-up mist-net surveys for NLEB should be conducted if warranted, 3) capture NLEB in order to confirm sex, age, and reproductive status of individual bats, and 4) locate NLEB roost trees within the Project should individuals be captured.

The following report summarizes the results of presence/probable absence surveys conducted during summer 2017.

Study Area

The proposed Project is located in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa. The Project area encompasses approximately 23,832 hectares (ha; 58,890 acres [ac]; see Appendix A). According to the U.S. Geological Survey National Land Cover Dataset (USGS NLCD 2006), the dominant land cover type within the Project is cultivated cropland, primarily corn and soybeans, covering 89.9% of the land area. The second most common cover type is emergent herbaceous wetlands (3.2%), followed by developed open space (3.1%), herbaceous (1.4%), and open water (0.7%). Deciduous forests, mixed forest, and woody wetlands are considered potential habitat for NLEB and make up a total of 0.5% of all land cover types within the Project. All other land cover types total less than 1.0% of the land area, individually. Developed areas are found at residences and farms scattered throughout the Project.

Based on habitat assessment of the original Project area and U.S. Fish and Wildlife Service (USFWS) recommendations, a total of 310 acres has been identified as potential NLEB suitable habitat. After finalizing project boundaries, a total of 304 acres of potential suitable NLEB habitat were identified in Jackson County, MN and Dickinson and Osceola counties, IA.

WEST sampled a total of 4 acoustic sites for NLEB following the summer survey guidance (USFWS 2017). No additional follow-up mist-net surveys were required at either of the acoustic sites.

OVERVIEW OF BAT DIVERSITY

There are seven species of bats found in Jackson County, MN and Dickinson and Osceola counties, IA. Those species include: the big brown bat (*Eptesicus fuscus*), silver-haired bat (*Lasionycteris noctivagans*), eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), little brown bat (*M. lucifugus*), NLEB, and tri-colored bat (*Perimyotis subflavus*). Of the seven species with the potential to occur in Minnesota, one (NLEB) is federally listed as threatened under the Endangered Species Act [ESA]. With the spread of white-nose syndrome (WNS) throughout the Midwest and Eastern US, several once common and abundant bat species, such as the little brown bat and northern long-eared bat, are experiencing population declines (Frick et al. 2010, USFWS 2013).

METHODS

Acoustic Surveys

WEST conducted acoustic surveys following guidance described in the *2017 Range-Wide Indiana Bat Summer Survey Guidelines*, which is also used for NLEB presence/probable absence surveys (USFWS 2017) and the *NLEB Interim Conference and Planning Guidance* (USFWS 2014).

Acoustic surveys were conducted at four survey sites, during a time period consistent with USFWS guidelines (June 17 – 20; 2017; USFWS 2014, 2017). Bats were surveyed using SM4BAT™ ultrasonic detectors (Wildlife Acoustics, Inc., Maynard, MA). WEST placed detectors in suitable habitat for NLEB, including forest edges, small clearings and forest-canopy openings, near water sources and/or forested riparian edges. Detectors were placed in areas with open tree canopies or canopy heights greater than 33 ft (10 m) and were spaced at least 656 ft (200 m) apart. Detectors were elevated at least 9.8 ft. (3.0 m) above ground level (AGL) to minimize acoustic interference from vegetation. Acoustic monitoring began before sunset and continued for the entire night. Survey duration at each site was a minimum of four detector nights (two detectors for two nights).

If weather conditions, such as persistent rain (more than 30 minutes), strong winds (greater than nine miles per hour [mph; 14 kilometers per hour (kph)] for more than 30 minutes), or persistent cold temperatures (below 10 degrees Celsius [°C; 50 degrees Fahrenheit (°F)] for more than 30 minutes), occurred during the first five hours of a survey night, then the survey was conducted for an additional night (USFWS 2014, 2017). Weather conditions were checked with the following weather stations, which can be found on Weather Underground's Wundermap (http://www.wunderground.com/wundermap/): Worthington, MN.

Bat calls were quantitatively identified using Kaleidoscope (version 4.2.0; Bats of North America classifier version 4.2.0; Wildlife Acoustics. Using Kaleidoscope, the appropriate state (Minnesota) from the Bats of North America classifier (version 4.2.0) was selected, and the Most Sensitive (i.e., most liberal) setting was used. All calls identified as NLEB by automated ID software were verified via qualitative call analysis by a biologist experienced with acoustic identification and who met required USFWS qualifications (Dr. Kevin Murray; USFWS 2017). As well, if a night exceeded the maximum likelihood threshold (p-value < 0.05) for NLEB, all files from that night received qualitative review. If call sequences were not characteristic of NLEB bats, contained distinct calls produced by species other than NLEB bats, or were of insufficient quality, they were reclassified as another species or as unknown. NLEB were considered present at sites with probable NLEB calls flagged by automated analysis and verified by qualitative review. NLEB were considered likely absent from sites with no probable NLEB bat calls or from sites with probable NLEB bat calls that were overruled by qualitative analysis.

RESULTS

Acoustic Surveys

WEST conducted acoustic surveys from June 17 – 20, 2017. Universal Transverse Mercator (UTM) coordinates and brief site descriptions for each site are listed in Table 1. Maps and photographs of acoustic survey sites are included in Appendix A and B, respectively. Acoustic surveys were completed at four sites for a total of 16 valid detector nights (Table 2). Due to inclement weather or technical issues with the equipment, an additional night was sampled at all locations.

The number of bat calls per detector night varied between the survey sites (27 to 394 bat calls per detector night), with an average of 61.2 bat calls per detector night within the Project (Table 2). Kaleidoscope identified 1,468 bat call files and identified 1,324 files to species (90.2%; Tables 2 and 3).

Automated acoustic ID software identified potential NLEB calls at 4 site locations (sites TW-1a, TW-2a, TW-3b, and TW-4a). Qualitative analysis of these potential bat calls determined the calls were not indicative of NLEB. Based on these data, NLEB are considered to be likely absent at all acoustic survey sites within the Project. Follow-up mist-netting was not required due to the lack of positive NLEB calls.

CONCLUSION

To meet the objectives of the study, acoustic surveys were conducted to determine presence/probable absence of NLEB within the Project. Based on the acoustic survey results, it was determined that there was likely summer absence of the federally listed NLEB at all survey sites within the Project. WEST's surveys in 2017 provided no indication that WNS has impacted local bat populations.

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TABLES

Table 1. Location and site description of 2017 acoustic survey sites at the Three Waters Wind Energy Project

Site ID	UTM Zone	Easting	Northing	Site Description
TW-1a	15	311800	4823885	forest/field edge
TW-1b	15	311938	4824012	forest/field edge
TW-2a	15	309341	4824040	forest/field edge
TW-2b	15	309414	4824138	forest/field edge
TW-3a	15	314510	4829184	forest/field edge
TW-3b	15	314683	4829303	forest/field edge
TW-4a	15	320878	4829991	forest/field edge
TW-4b	15	320954	4829843	forest/field edge

Table 2. Number of bat calls identified by Kaleidoscope during 2017 northern long-eared bat surveys at the Three Waters Wind Energy Project.

Survey Site	Total Bat Calls	Calls Identified	Detector-Nights	Bat Calls/ Detector-Night
TW-1a	259	234	3	86.3
TW-1b	327	314	3	109.0
TW-2a	240	217	3	80.0
TW-2b	394	342	3	131.3
TW-3a	78	70	3	26.0
TW-3b	67	63	3	22.3
TW-4a	76	64	3	25.3
TW-4b	27	20	3	9.0
Total	**1,468**	**1,324**	**24**	**61.2**

Table 3. Species identified by Kaleidoscope during 2017 northern long-eared bat surveys at the Three Waters Wind Energy Project. EPFU=Big Brown Bat; LABO=Eastern Red Bat; LACI=Hoary Bat; LANO=Silver-haired Bat; MYLU=Little Brown Bat; NLEB=Northern Long-eared Bat; PESU=Tri-colored Bat; UNK=Unknown.

Site ID	EPFU	LABO	LACI	LANO	MYLU	NLEB	PESU	UNK	Total
TW-1a	135	80	3	0	13	1	2	25	**259**
TW-1b	169	129	2	5	2	0	7	13	**327**
TW-2a	36	0	167	11	2	1	0	23	**240**
TW-2b	272	0	41	24	5	0	0	52	**394**
TW-3a	5	52	11	0	1	0	1	8	**78**
TW-3b	28	18	9	2	3	1	2	4	**67**
TW-4a	24	21	8	0	9	2	0	12	**76**
TW-4b	5	7	5	2	1	0	0	7	**27**

Appendix A. Maps of Northern Long-Eared Bat Surveys

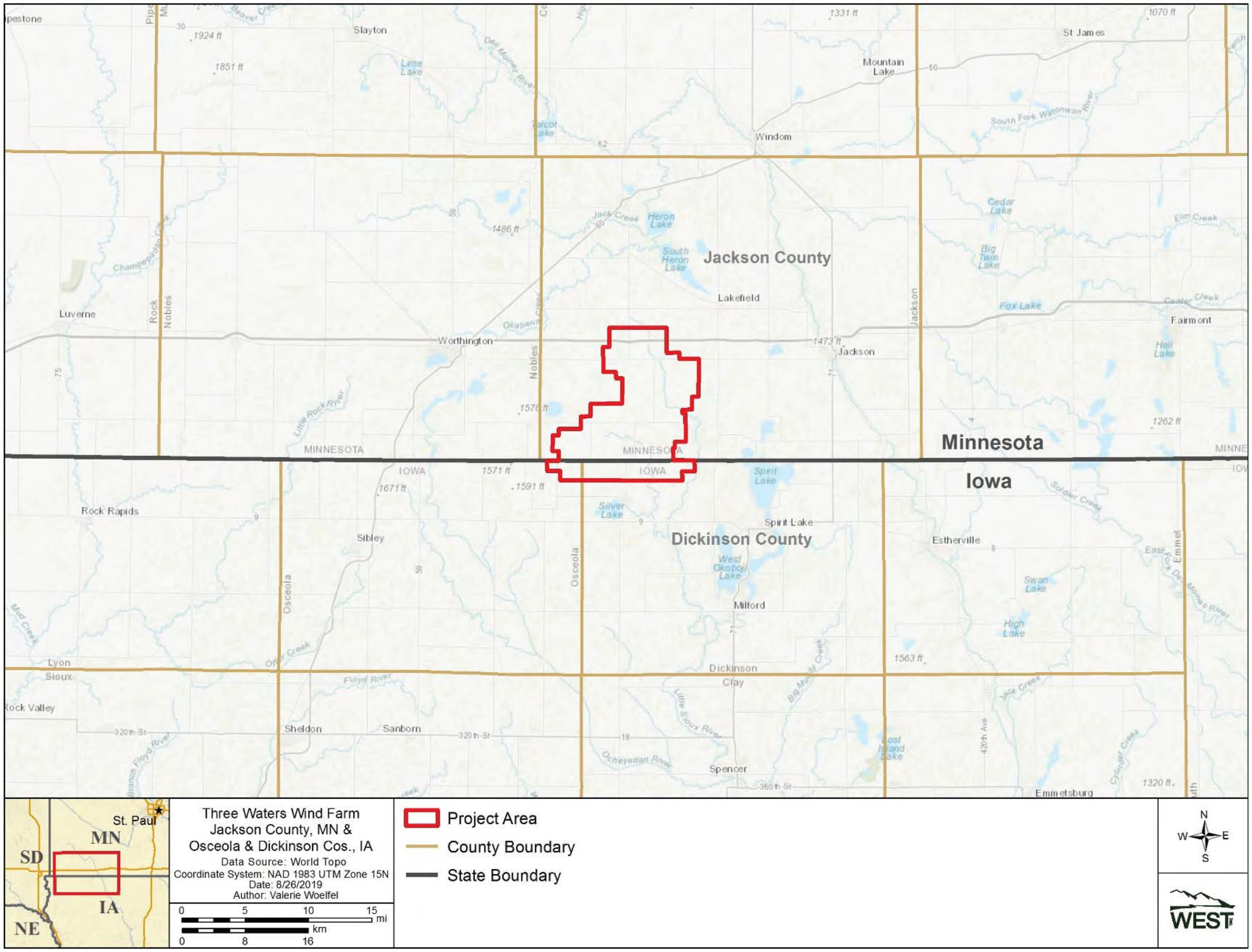

Figure 1. Location of the Three Waters Wind Farm

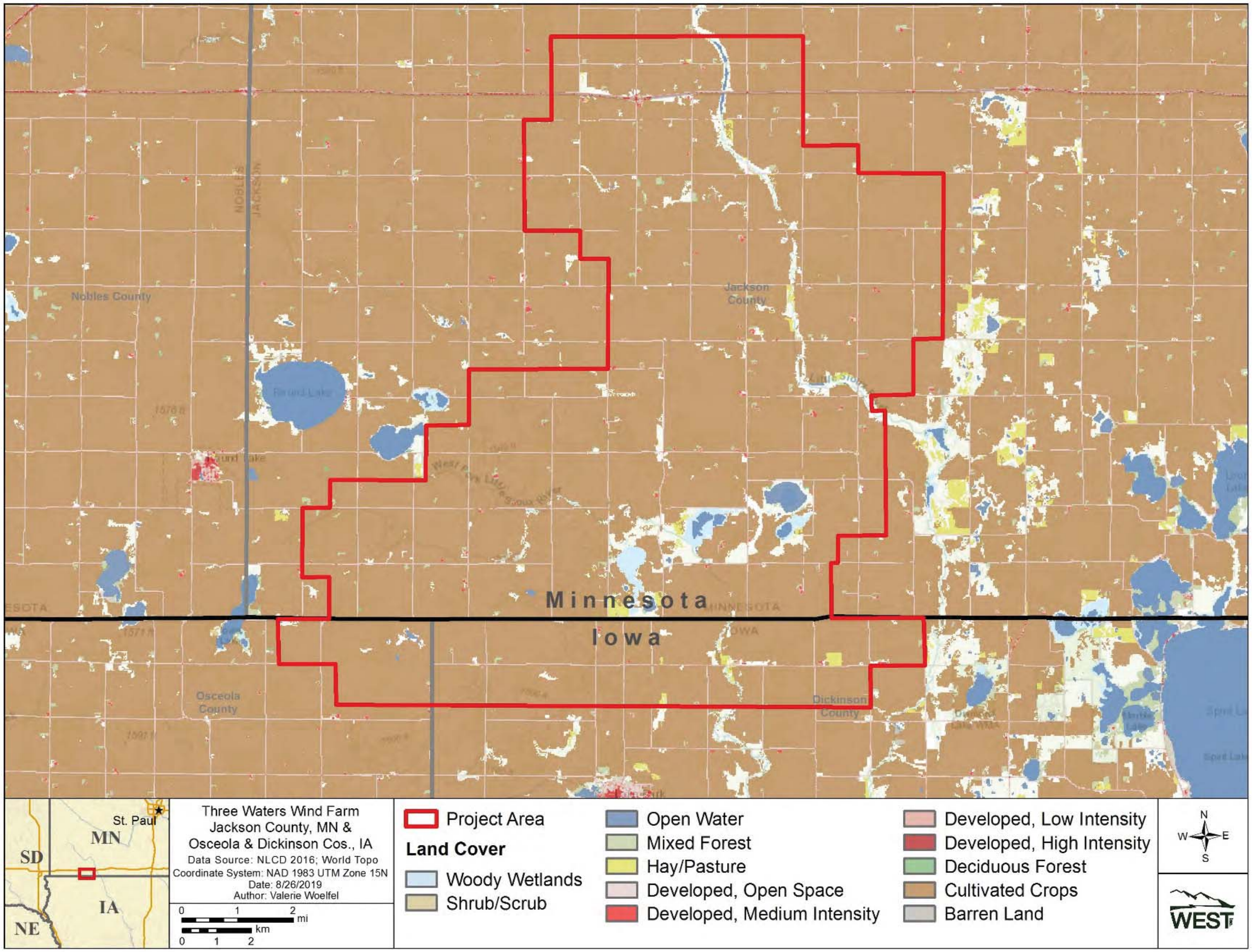

Figure 2. Land use and land cover at the Three Waters Wind Farm.

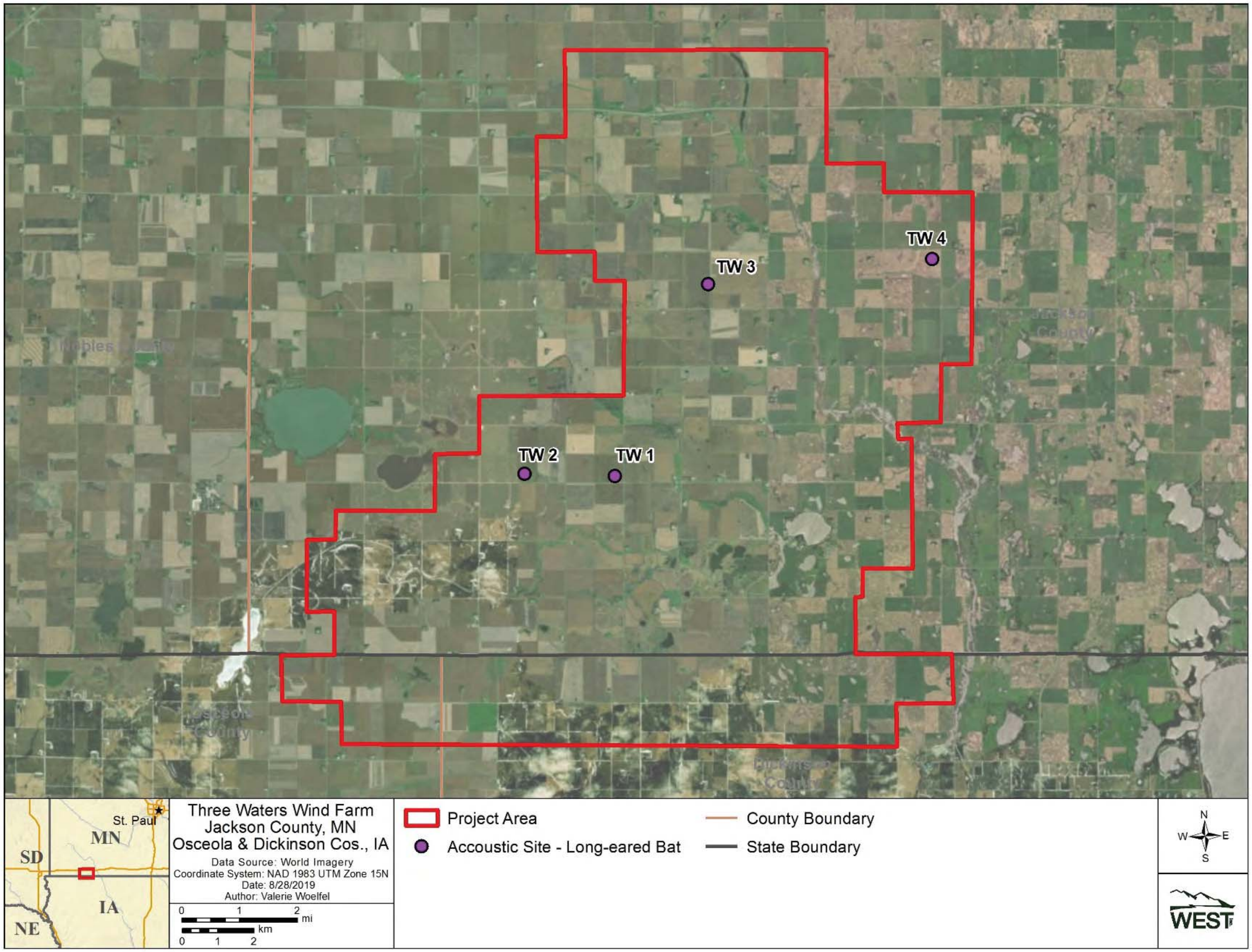

Figure 3. Acoustic survey locations at the Three Waters Wind Farm.

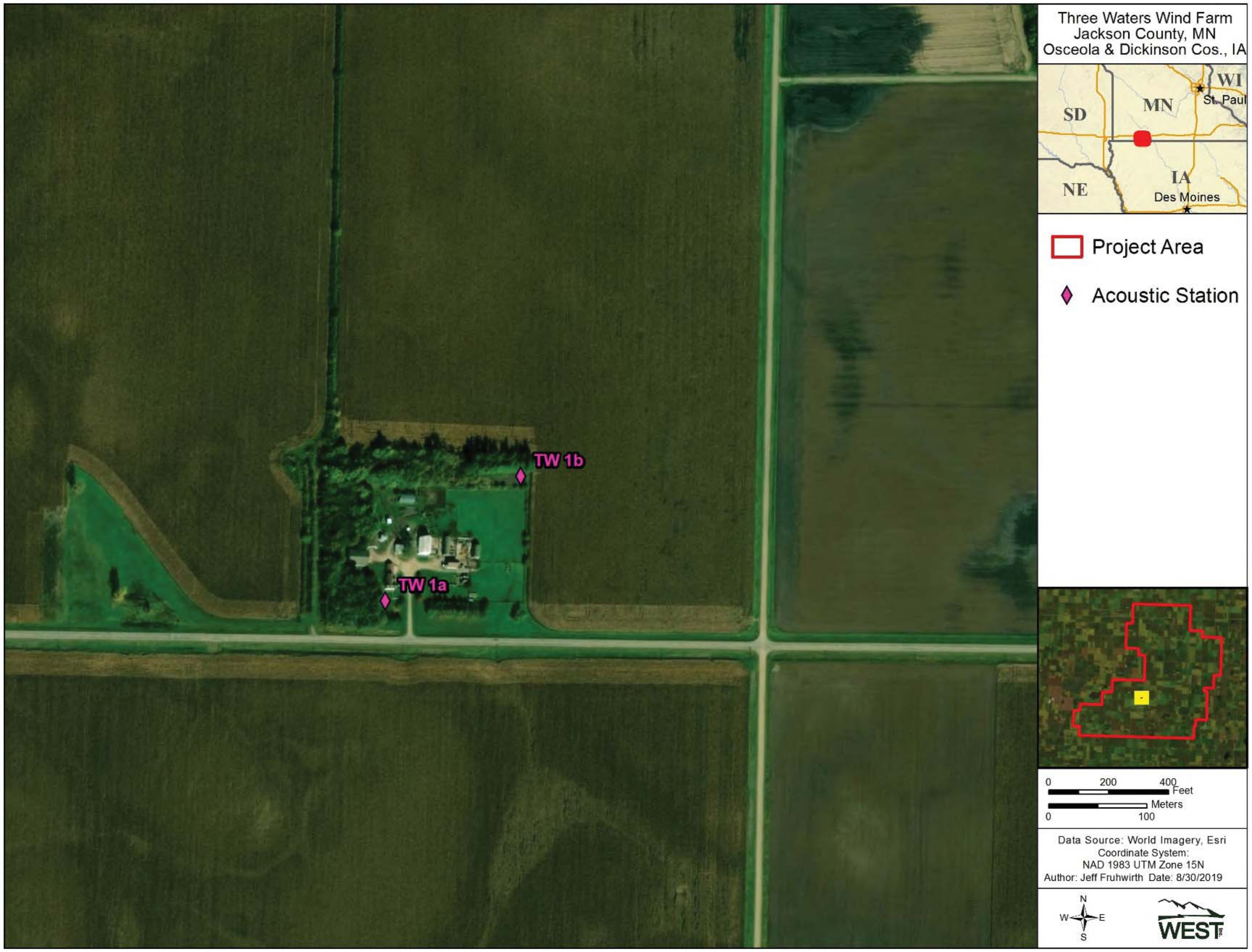

Figure 4. Close up map of acoustic survey TW-1 at the Three Waters Wind Farm.

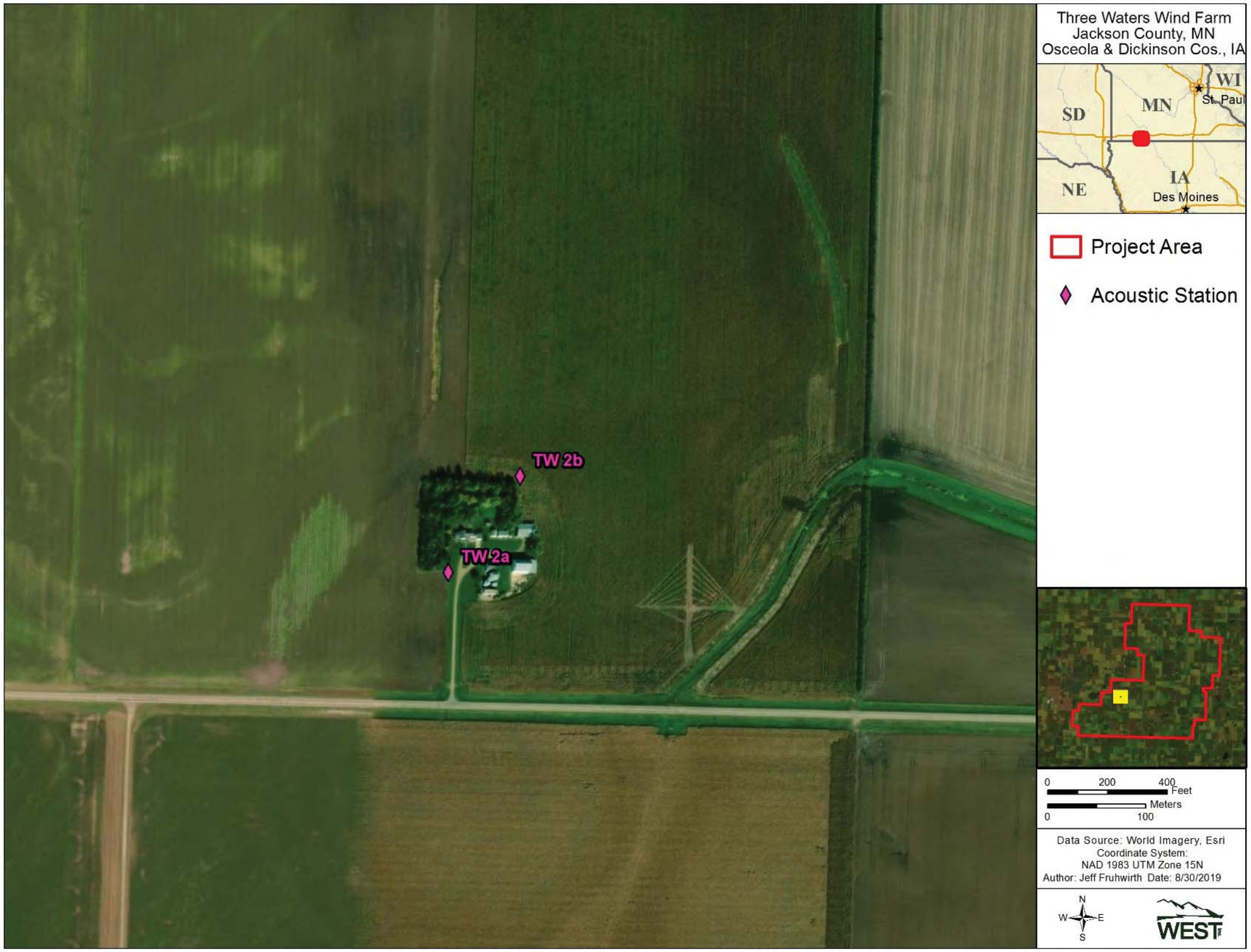

Figure 5. Close up map of acoustic survey TW-2 at the Three Waters Wind Farm.

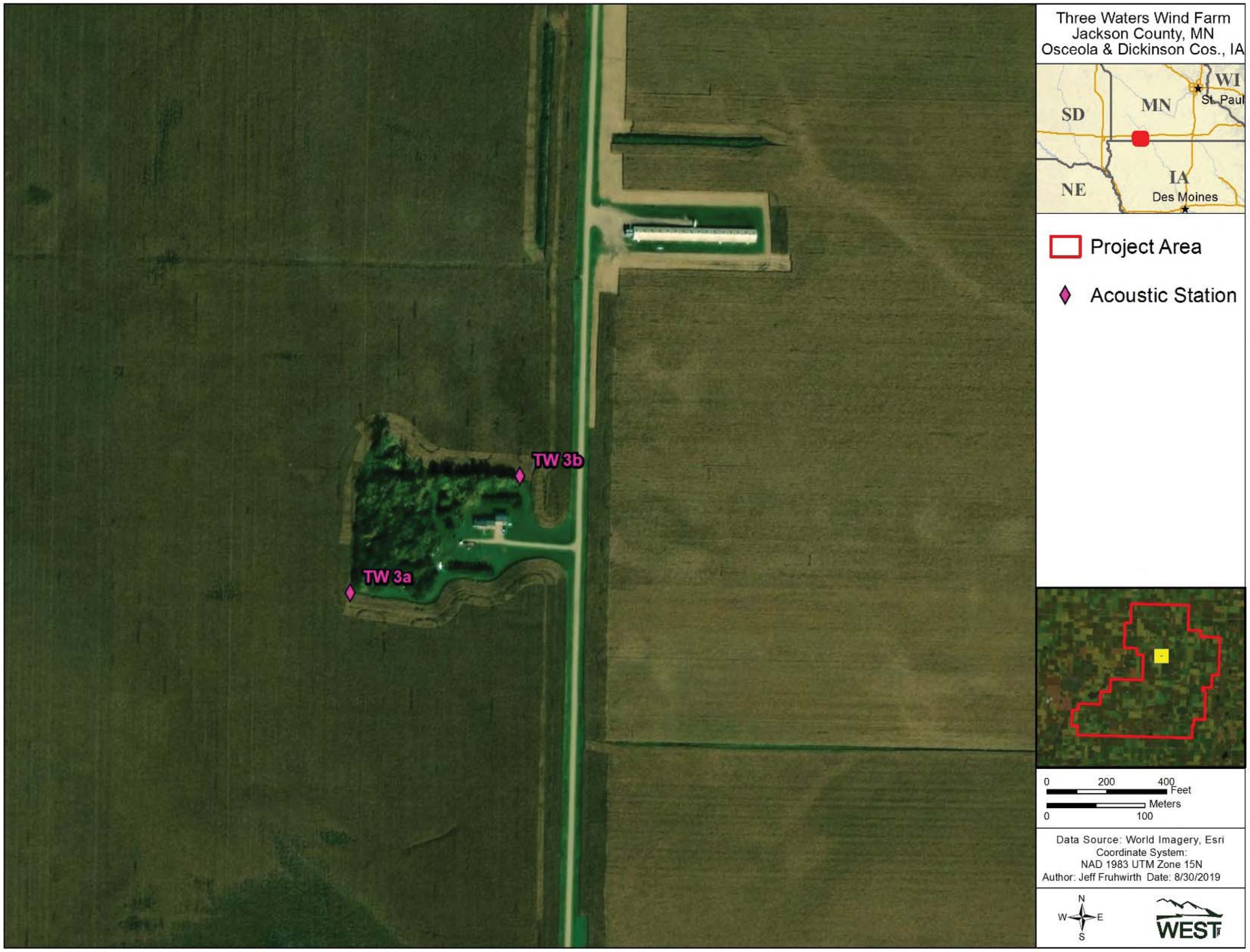

Figure 6. Close up map of acoustic survey TW-3 at the Three Waters Wind Farm.

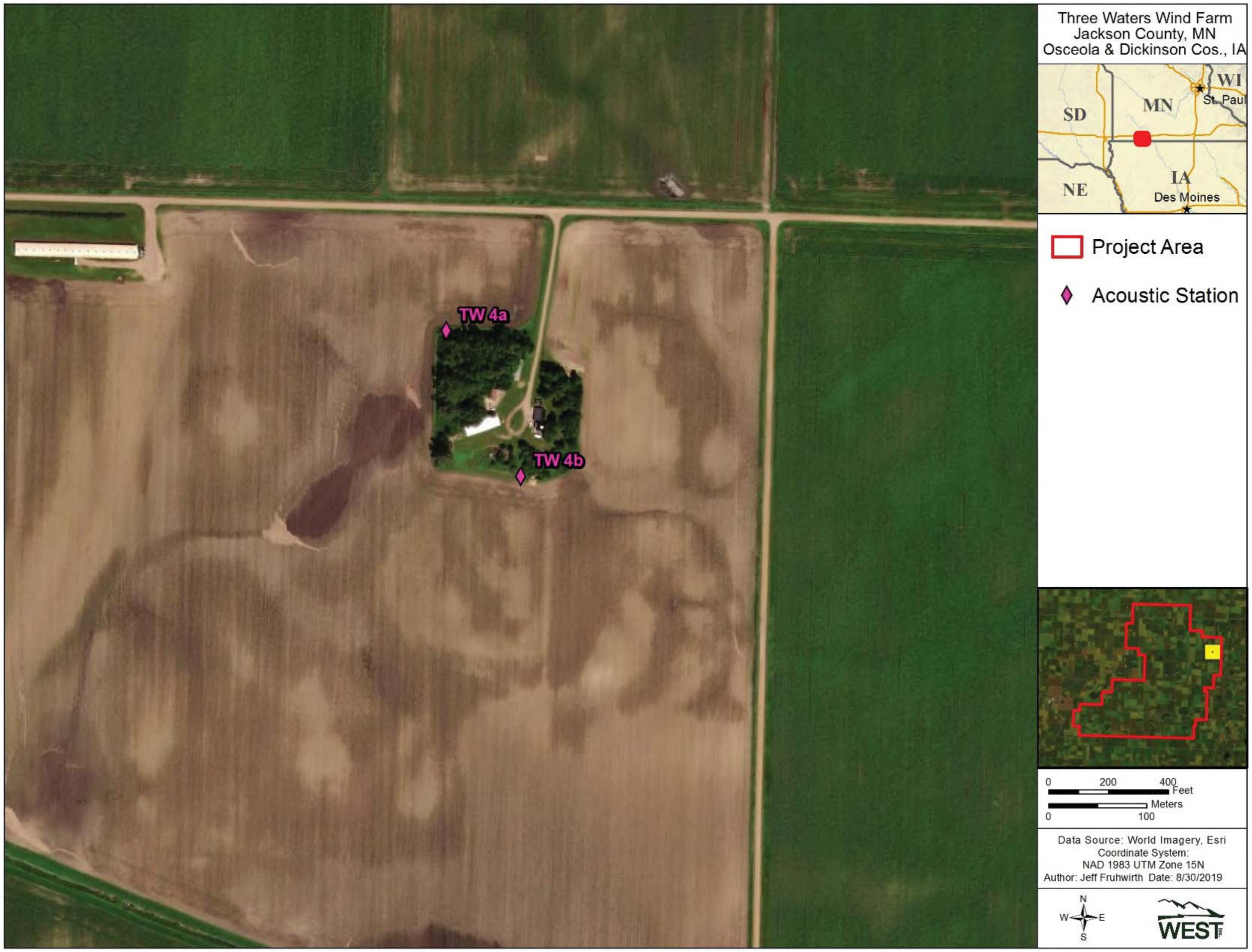

Figure 7. Close up map of acoustic survey TW-4 at the Three Waters Wind Farm.

Appendix B. Photographs of Acoustic Survey Sites



Appendix B1. Acoustic survey TW-1a.

Appendix B1. Acoustic survey TW-1b.



Appendix B2. Acoustic survey TW-2a.

Appendix B2. Acoustic survey TW-2b.

Appendix B3. Acoustic survey TW-3a.



Appendix B3. Acoustic survey TW-3b.

Appendix B4. Acoustic survey TW-4a.



Appendix B4. Acoustic survey TW-4b.

Bird and Bat Conservation Plan

Bird and Bat Conservation Strategy

Three Waters Wind Farm

Jackson County, Minnesota
Dickinson and Osceola Counties, Iowa

Prepared for:

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August 2019

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1 INTRODUCTION

Although wind energy facilities use a renewable resource, their construction and operation can impact birds and bats. Interactions with wind turbines and associated infrastructure, such as energy transmission lines, distribution lines, and substations, may result in fatalities or indirect effects such as displacement or habitat loss. To address these concerns, Three Waters Wind Farm, LLC (Three Waters) contracted Western EcoSystems Technology, Inc. (WEST) to develop this Bird and Bat Conservation Strategy (BBCS) for the Three Waters Wind Farm (Project) in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa. This BBCS outlines processes that Three Waters has or will employ to: 1) comply with state and federal laws and regulations that protect bird and bat species; 2) ensure potential impacts to bird and bat species are identified, quantified, and analyzed; and 3) avoid, minimize, and mitigate potential effects consistent with the US Fish and Wildlife Service (USFWS) *Land-Based Wind Energy Guidelines* (WEG; USFWS 2012) and the Minnesota Department of Natural Resources (MNDNR) *Avian and Bat Survey Protocols for Large Wind Energy Conversion Systems in Minnesota* (Mixon et al 2014).

Federal laws and regulations protect the majority of birds found in and around the Project area, including the Migratory Bird Treaty Act of 1918 (MBTA), the Bald and Golden Eagle Protection Act of 1940 (BGEPA), and the federal Endangered Species Act of 1973 (ESA). The purpose of the BBCS is to meet the intent of these regulations and guidelines by reducing and managing the risk to bird and bat species. This BBCS has been voluntarily prepared as a good faith effort by Three Waters to proactively address potential impacts to birds and bats that may result from construction and operation of the Project.

Three Waters has developed this BBCS to meet the following objectives:

1) Document and describe the scope of the Project, the biological survey work that was completed pre-construction, and provide an assessment of risks to bird and bat resources posed by the Project. This objective includes providing a single point of reference for information related to avian and bat studies performed in relation to the Project.
2) Provide a plan that avoids, minimizes, or monitors potential effects to bird and bat species resulting from construction and operation of the Project consistent with the WEG.
3) Describe post-construction monitoring efforts that will continue to be implemented at the Project to identify impacts to birds and bats, as well as the methods for reporting the monitoring results.
4) Outline the adaptive management framework that Three Waters has committed to over the life of the Project.
5) Provide an educational and practical reference for Three Waters' employees and contractors to facilitate the application of measures that avoid and minimize potential negative effects to avian and bat species at the Project.

2 SITE AND PROJECT DESCRIPTION

The Project area is in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa (Figure 1). The Project area includes 23,832 hectares (ha; 58,890 acres [ac]), most (89.9%) of which is cultivated cropland (Table 1; Figure 2). Smaller areas of emergent herbaceous wetlands (3.2%); developed, open space (3.1%); and herbaceous (1.4%) land cover also occur in the Project area (Table 1). The remaining land cover types each compose less than 1% of the total area (Table 1). Segments of the Little Sioux River, the West Fork of the Little Sioux River, and other small drainages run through the Project area (Figure 2). Several small lakes and ponds, including Illinois Lake, Skunk Lake, Rush Lake, and Iowa Lake, also occur in the Project area (Figure 2).

Table 1. Land cover types, coverage, and composition within the Three Waters Wind Farm in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

Habitat	Hectares	Acres	% Composition
Cultivated Crops	21,411.7	52,910.4	89.9
Emergent Herbaceous Wetlands	764.1	1,888.1	3.2
Developed, Open Space	735.9	1,818.5	3.1
Herbaceous	335.5	829.0	1.4
Open Water	160.8	397.3	0.7
Hay/Pasture	128.3	317.0	0.5
Developed, Low Intensity	119.7	295.9	0.5
Mixed Forest	107.2	264.8	0.5
Developed, Medium Intensity	33.9	83.9	0.1
Deciduous Forest	10.4	25.6	<0.1
Shrub/Scrub	9.5	23.6	<0.1
Barren Land	6.1	15.1	<0.1
Woody Wetlands	5.6	13.8	<0.1
Developed, High Intensity	2.7	6.7	<0.1
Total[1]	**23,832**	**58,890**	**100**

Data from the National Land Cover Database (Yang et al. 2018, Multi-Resolution Land Characteristics 2019).

[1] Sums of values may not add to total value shown due to rounding.

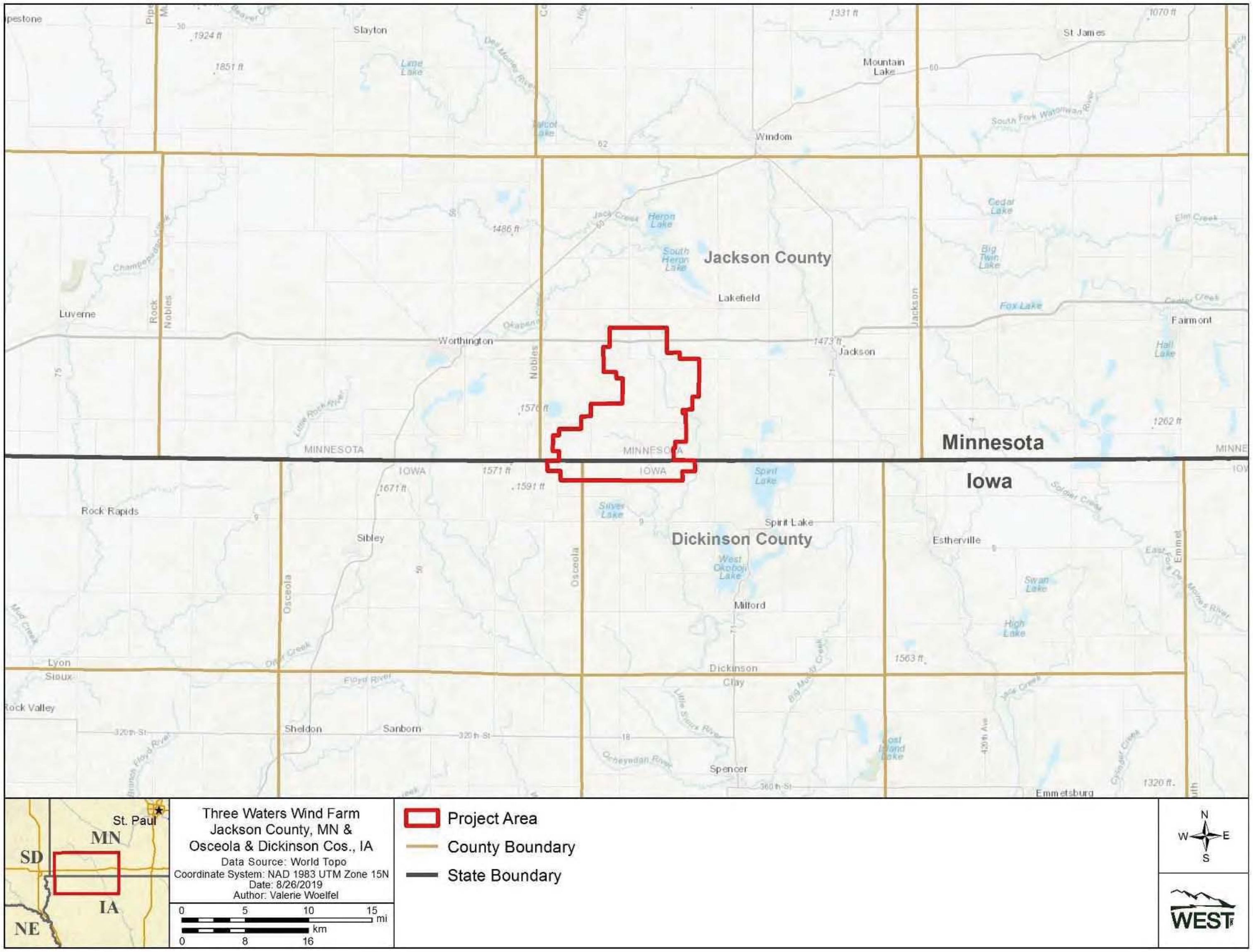

Figure 1. Location of the Three Waters Wind Farm in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

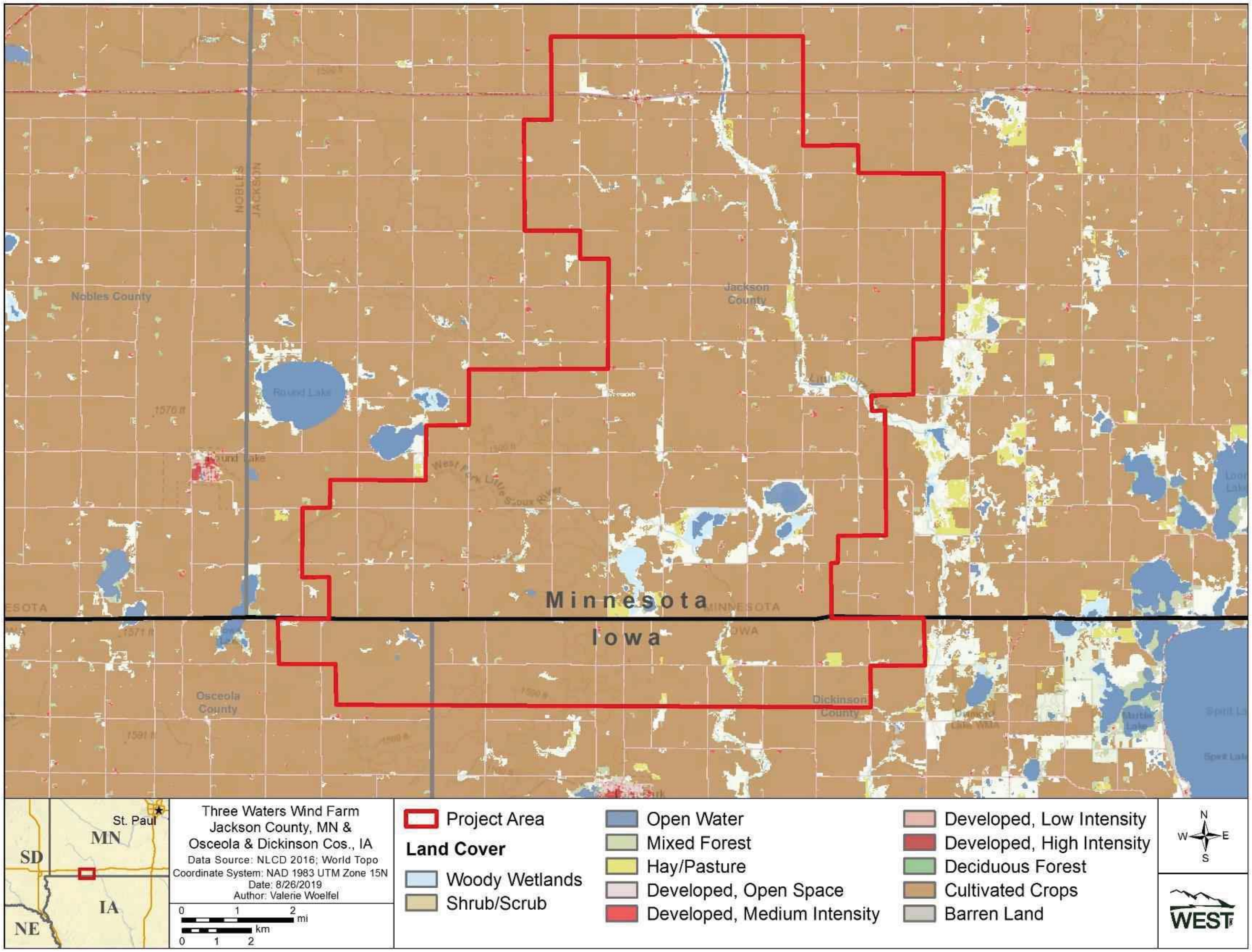

Figure 2. Land cover in the Three Waters Wind Farm (Yang et al. 2018, Multi-Resolution Land Characteristics 2019) in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

3 REGULATORY REQUIREMENTS RELEVANT TO THIS BBCS

3.1 Federal Endangered Species Act

Species at risk of extinction, including many birds and bats, are protected under the federal ESA of 1973, as amended. The purpose of the ESA is to protect threatened and endangered species and to provide a means to conserve their habitats. Take under the ESA is defined as "…to harass, harm, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." Harm is an act which injures or kills a wildlife species, including significant habitat modification or degradation; whereas harass is defined as an intentional or negligent act or omission which creates the likelihood of injury by annoying the animal to the extent it significantly disrupts normal behavior patterns such as breeding, feeding, or sheltering. The ESA authorizes the USFWS to issue permits for "incidental take" of wildlife species, which is take resulting from an otherwise lawful activity.

3.2 Migratory Bird Treaty Act

The MBTA integrates and implements four international treaties that provide for the protection of migratory birds. The MBTA prohibits the taking, killing, possession, transportation, import and export of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior." (16 United States Code [USC] 703 [1918]). The word "take" is defined under the MBTA as "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect." (50 Code of Federal Regulations [CFR] 10.12 [1973]). The USFWS maintains a list of all species protected by the MBTA at 50 CFR 10.13 (1973). This list includes over one thousand species of migratory birds, including eagles and other raptors, waterfowl, shorebirds, seabirds, wading birds, and passerines.

On December 22, 2017, the US Department of Interior (USDOI) issued a Solicitor's Opinion (USDOI 2017) followed by the USFWS Guidance Memorandum on April 11, 2018 (USFWS 2018a), both of which clarified the following with regards to enforcement of the MBTA: 1) the MBTA's take prohibitions only apply when the purpose of an action is "take" of migratory birds, their eggs, or their nests; 2) the project's impacts on migratory birds should still be considered during the National Environmental Policy Act of 1969 (NEPA) review process; 3) future settlement agreements for take of listed species or eagles should not include restrictions, minimization measures, or mitigation for purposes of MBTA compliance; 4) future permits under the ESA or BGEPA, or inter-agency consultations under Section 7 of the ESA, should not include restrictions, minimization measures, or mitigation for purposes of MBTA compliance; and 5) the MBTA does not affect protections provided under the ESA or the BGEPA (Locke Lord 2018).

3.3 Bald and Golden Eagle Protection Act

The BGEPA provides legal protection to bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*; 16 USC 668-668d [1940]). The BGEPA prohibits the take, sale, purchase, barter, offer of sale, transport, export or import, at any time or in any manner of any bald or golden eagle, alive or dead, or any part, nest, or egg thereof. The BGEPA also defines take to include "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb," (16 USC 668c [1940]), and includes criminal and civil penalties for violating the statute (see 16 USC 668 [1940]). The USFWS further defined the term "disturb" as agitating or bothering an eagle to a degree that causes, or is likely to cause, injury, or either a decrease in productivity or nest abandonment by substantially interfering with normal breeding, feeding, or sheltering behavior.

In September 2009, the USFWS promulgated a final rule on two new permit regulations that specifically authorize under the BGEPA the non-purposeful (i.e., incidental) take of eagles and eagle nests in certain situations (see 50 CFR 22.26 [2009] and 22.27 [2009]). Revisions to the final rule were issued in December 2016. The permits authorize limited take of bald and golden eagles; authorizing individuals, companies, government agencies and other organizations to disturb or otherwise take eagles in the course of conducting lawful activities. To facilitate issuance of Eagle Take Permits (ETPs) for wind energy facilities the USFWS finalized the *Eagle Conservation Plan Guidance* (ECPG) - *Module 1 - Land-based Wind Energy Version 2* (USFWS 2013). If eagles are identified as a potential risk at a project site, developers are encouraged to follow the ECPG. The ECPG describes specific actions recommended to achieve compliance with the regulatory requirements in the BGEPA for an ETP, as described in 50 CFR 22.26 (2009) and 22.27 (2009). The ECPG provides a national framework for assessing and mitigating risk specific to eagles through development of Eagle Conservation Plans (ECPs) and issuance of programmatic ETPs at wind energy facilities.

3.4 Minnesota State Threatened and Endangered Species

The Minnesota legislature has authorized regulations pertaining to the management, regulation, and protection of native animals listed as state threatened or endangered. Species of fish or wildlife indigenous to Minnesota are endangered if threatened with statewide extinction throughout all or much of its range as filed by the commissioner of the Minnesota Department of Natural Resources (MNDNR). A threatened animal species is any species that MNDNR has determined is likely to become endangered in the future. No person may take, import, transport, or sell any portion of an endangered wild animal or plant species, or sell or possess with intent to sell an article made with any part of the skin, hide, or parts of an endangered wild animal or plant species; certain exemptions apply (subdivisions 2 and 7 of Minnesota Statues, section 84.0895). The Minnesota Endangered Species Statue and the associated rules establish a variety of restrictions, permitting programs, and exemptions pertaining to state-listed threatened and endangered species.

4 AGENCY CONSULTATION

The WEG encourages energy developers to coordinate with agencies regarding bird, bat or other wildlife issues within a project area. Agencies can help developers identify potential natural resource issues early in the development process. Three Waters has coordinated with the MNDNR and the USFWS Ecological Services Field Office in St. Paul, Minnesota (Table 2) and has committed to continued coordination as necessary throughout the life of the Project.

Table 2. Summary of agency coordination regarding the Three Waters Wind Farm in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

Date	Attendees	Meeting Topics
May 8, 2017	Three Waters WEST MNDNR MNDOC USFWS	Survey description; Upcoming studies
August 13, 2018	Three Waters WEST MNDNR USFWS	Completed studies; Upcoming studies
August 5, 2019	Three Waters WEST MNDNR	Completed studies

WEST = Western EcoSystems Technology, Inc.
MNDNR = Minnesota Department of Natural Resources
MNDOC = Minnesota Department of Commerce
USFWS = US Fish and Wildlife Service

5 SITE CHARACTERIZATION – TIERS 1 and 2

The WEG outlines a tiered approach for assessing habitat suitability and risks to wildlife at a potential wind energy site (USFWS 2012). At each tier, potential issues associated with the development or operation of a project are identified and questions are asked to guide the decision process. This process starts at a broad scale and provides more site-specific detail at each tier as more data are gathered and potential risks are better understood. This approach ensures that sufficient data are collected to enable Three Waters to make informed decisions regarding further development of the Project.

Tiers 1 and 2 provide a framework for evaluating potential issues that should be addressed before development of the Project continues. Tier 1 studies provide a preliminary desktop evaluation of public data from federal, state, and tribal entities and offer early guidance on potential risks to natural resources at the site. This information can help the developer identify sites where development may pose significant risks to natural resources. Tier 2 studies determine potential effects of a proposed project on sensitive species. Tier 2 studies typically include a more substantive review of available data on sensitive species and wildlife habitat within or near a project.

Three Waters developed a Site Characterization Study (SCS; McDonald et al. 2019). This study followed recommendations in the WEG for tiers 1 and 2 and recommendations in the ECPG for a Stage 1 Initial Site Assessment, which includes more detail on potential risks to eagles. The SCS identified sensitive species that may be impacted by development or operation of the Project. Sensitive species included federally or state-protected species (Table 3) and Birds of Conservation Concern (Table 4). The SCS also identified all bat species that could occur in the Project area (Table 5).

Table 3. Bird and bat species listed as state or federally threatened, endangered, or otherwise protected that could occur at the Three Waters Wind Farm in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

Common Name	Scientific Name	Status
	Bats	
Northern Long-eared Bat	*Myotis septentrionalis*	FT
	Birds	
Bald Eagle	*Haliaeetus leucocephalus*	BGEPA
Golden Eagle	*Aquila chrysaetos*	BGEPA
Burrowing Owl	*Athene cunicularia*	SE
Henslow's Sparrow	*Ammodramus henslowii*	SE
King Rail	*Rallus elegans*	SE
Loggerhead Shrike	*Lanius ludovicianus*	SE
Wilson's Phalarope	*Phalaropus tricolor*	ST

BGEPA = Bald and Golden Eagle Protection Act (1940);

FT = Federally Threatened (USFWS 2014);

SE = State Endangered (MNDNR 2016);

ST = State Threatened (MNDNR 2016)

Table 4. US Fish and Wildlife Service Migratory Birds of Conservation Concern that could occur at the Three Waters Wind Farm in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

Common Name	Scientific Name
Bald Eagle	*Haliaeetus leucocephalus*
Black Tern	*Chlidonias niger*
Bobolink	*Dolichonyx oryzivorus*
Dunlin	*Calidris alpina*
Franklin's Gull	*Leucophaeus pipixcan*
Hudsonian Godwit	*Limosa haemastica*
Lesser Yellowlegs	*Tringa flavipes*
Marbled Godwit	*Limosa fedoa*
Red-Headed Woodpecker	*Melanerpes erythrocephalus*
Semipalmated Sandpiper	*Calidris pusilla*
Short-Billed Dowitcher	*Limnodromus griseus*

Source: US Fish and Wildlife Service 2018b

Table 5. Bat species (categorized by echolocation call frequency) that could occur at the Three Waters Wind Farm in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

Common Name	Scientific Name
High Frequency (>30 kilohertz [kHz])	
eastern red bat	*Lasiurus borealis*
little brown bat	*Myotis lucifugus*
northern long-eared bat	*Myotis septentrionalis*
evening bat	*Nycticeius humeralis*
tri-colored bat	*Perimyotis subflavus*
Low Frequency (15 – 30 kHz)	
big brown bat	*Eptesicus fuscus*
hoary bat	*Lasiurus cinereus*
silver-haired bat	*Lasionycteris noctivagans*

6 BIRD AND BAT ASSESSMENT: TIER 3

Three Waters conducted pre-construction bird and bat studies for the Project from 2017 to 2019. These included two years of avian use surveys, two years of aerial raptor nest surveys, two years of general bat acoustic surveys, and one year of northern long-eared bat (*Myotis septentrionalis*) presence/probable absence surveys.

6.1 Eagle and Large Bird Use Surveys

6.1.1 Methods

Eagle and other large bird use surveys were conducted within the Project area from March 2017 through February 2019 following guidelines in the ECPG and revised eagle permitting rule. The objective was to provide spatial and temporal information on eagle and other large bird use to help inform decisions on turbine siting and ways to avoid/minimize impacts to eagles and other large bird species.

Surveys consisted of counting eagles and other large birds within 18 circular plots centered on an observation point (Figure 3). All observations were recorded; however, analysis was restricted to observations within 800 meters (m; 2,625 feet [ft]) of the observer. The Rotor Swept Height (RSH) was defined as 25 to 150 m AGL. A Geographic Information System (GIS) software specialist assigned survey locations remotely in a spatially random design consistent with recommendations described in the ECPG and revised eagle permitting rule (Figure 3). Points were surveyed from a random start location to vary visitation times throughout the day during each season.

Surveys were conducted for one hour at each point once per month, for a total of 24 visits and 432 survey hours at each point over the two-year study. Each survey day began with a randomly selected survey location from all available remaining points to be surveyed. Surveys were conducted during daylight hours and survey times varied across daylight hours.

6.1.2 Year 1 Results

Two hundred sixteen fixed-point bird use surveys were conducted from March 24, 2017 – February 18, 2018. Thirty-five large bird species were identified over the course of all fixed-point bird use surveys. Species richness was greatest during the spring and lowest during the winter. The index to overall species richness was 1.22 large bird species/800-m plot/60-min survey.

Sensitive large bird species recorded during year one surveys included nine bald eagles, one golden eagle, three Swainson's hawks (*Buteo swainsoni*), seven northern harriers (*Circus hudsonius*), one peregrine falcon (*Falco peregrinus*), 145 American white pelicans (*Pelecanus erythrorhynchos*), 58 northern pintails (*Anas acuta*), 246 Franklin's gulls (*Leucophaeus pipixcan*), and 12 black terns (*Chlidonias niger*). Incidental observations of sensitive species included one bald eagle, two northern harriers, one semipalmated sandpiper, and one upland sandpiper.

There were 3,850 large bird observations recorded within 357 separate groups (defined as one or more individual) during these surveys. Of all large bird types, waterfowl and gulls/terns composed most of the large bird observations (1,769 and 1,405 observations, respectively). Ring-billed gull (*Larus delawarensis*) was the most abundant species recorded during large bird surveys (1,142 observations), followed by unidentified duck (826 observations) and Canada goose (*Branta canadensis*; 440 observations). Red-tailed hawks (*Buteo jamaicensis*) were the most abundant diurnal raptor species recorded (53 observations).

Overall large bird use was higher during spring (38.31 observations/800-m plot/60-min survey) and fall (29.11 observations/800-m plot/60-min survey) compared to summer (3.33 observations/800-m plot/60-min survey) and winter (0.46 observations/800-m plot/60-min survey). Waterfowl accounted for the highest percentage of the large bird use in spring, summer, and fall. Ring-billed gull had the highest use in spring, Canada goose had the highest use of all species during summer and fall, and American crow (*Corvus brachyrhynchos*) had the highest use during winter. . Diurnal raptor use was highest in fall (1.04 observations/800-m plot/60-min survey), followed by spring (0.59 observations/800-m plot/60-min survey), summer (0.11 observations/800-m plot/60-min survey), and winter (0.11 observations/800-m plot/60-min survey). Buteos made up most of the diurnal raptor use, largely due to higher use by red-tailed hawks. Bald eagle use was recorded in spring (0.06 observations/800-m plot/60-min survey), fall (0.04 observations/800-m plot/60-min survey), and winter (0.02 observations/800-m plot/60-min survey).

During large bird surveys, 19.2% of all flying large birds were within the RSH (i.e., between 25–150 m) when first observed, 27.1% were below the RSH (i.e., <25 m), and 53.7% were above the RSH (i.e., >25 m). Of flying diurnal raptors, 51.6% were within the RSH when first observed, 27.5% were below the RSH, and 20.9% were above the RSH. Diurnal raptor groups recorded most often within the RSH were Accipiters (66.7%) and Buteos (57.6%). Of the six bald eagle observations flying, two were within the RSH when first observed, one was below the RSH, and three were above the RSH.

An exposure index, based on initial flight height and use estimates, was calculated for each species. Ring-billed gull had the highest exposure index value of all large birds. Other species with exposure values greater than zero included mallard (*Anas platyrhynchos*), Canada goose, Franklin's gull, American white pelican, red-tailed hawk, turkey vulture (*Cathartes aura*), American crow, great blue heron (*Ardea herodias*), sharp-shinned hawk (*Accipiter striatus*), rough-legged hawk (*Buteo lagopus*), and northern harrier. Bald eagle exposure was relatively low (less than 0.01) and golden eagle exposure could not be calculated because the one observation was outside the 800-m survey plot.

Flight paths and perch locations of diurnal raptor species were digitized and mapped (Figures 5 and 6). Flight paths indicated no obvious movement corridors or areas of concentration. Mean use estimates suggest that overall large bird use is distributed relatively evenly throughout the Project area, with high use at Point 10 (66.67 observations/60-min survey; Figures 5 and 6). Diurnal raptors were observed at 17 of the 18 survey points, with higher use at Point 14 (1.17 observations/60-min survey). Eagles were observed at five survey points, with highest use at Point 9 (0.17 observations/60-min survey; Figures 4 and 5).

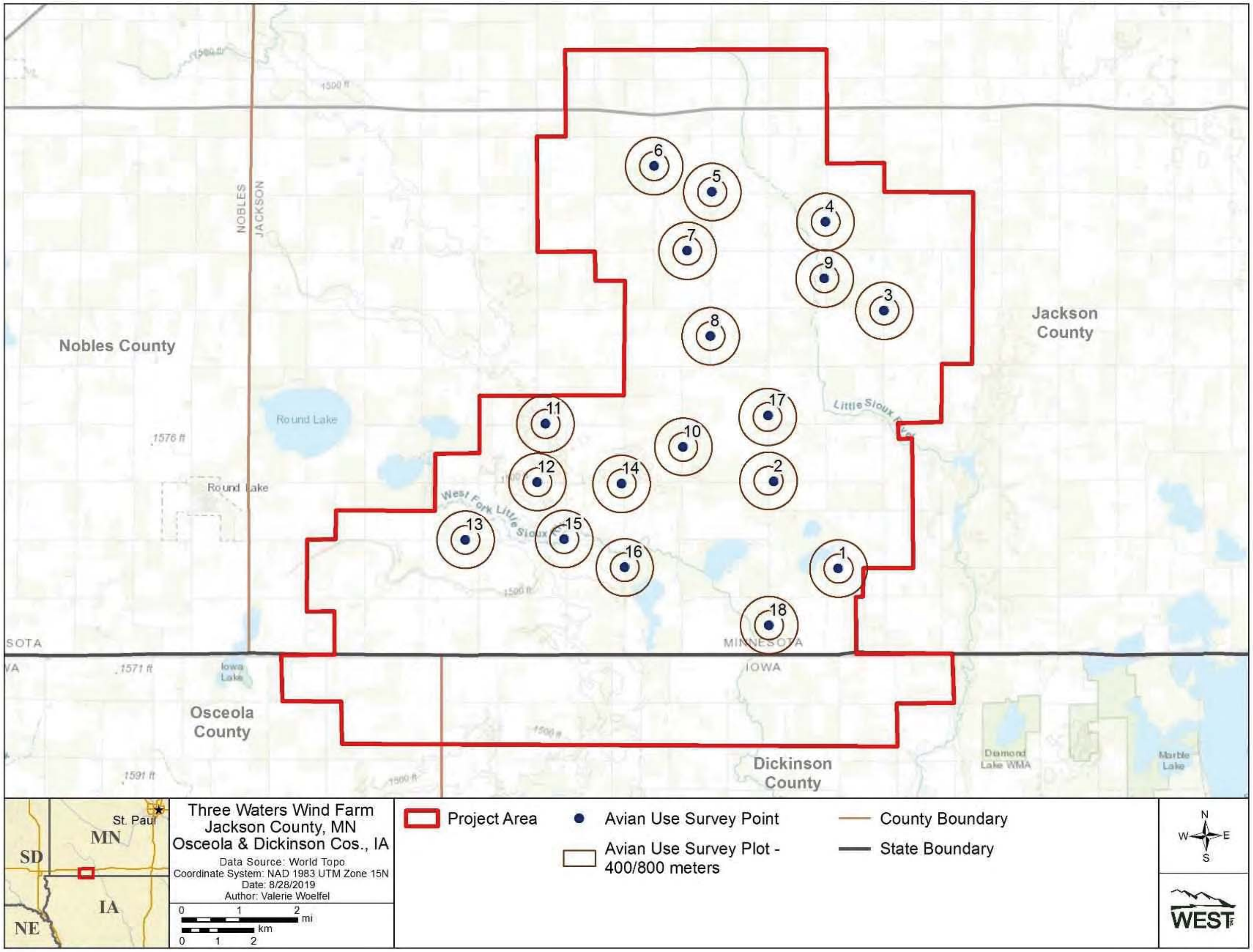

Figure 3. Location of fixed-point bird use surveys at the Three Waters Wind Farm, Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

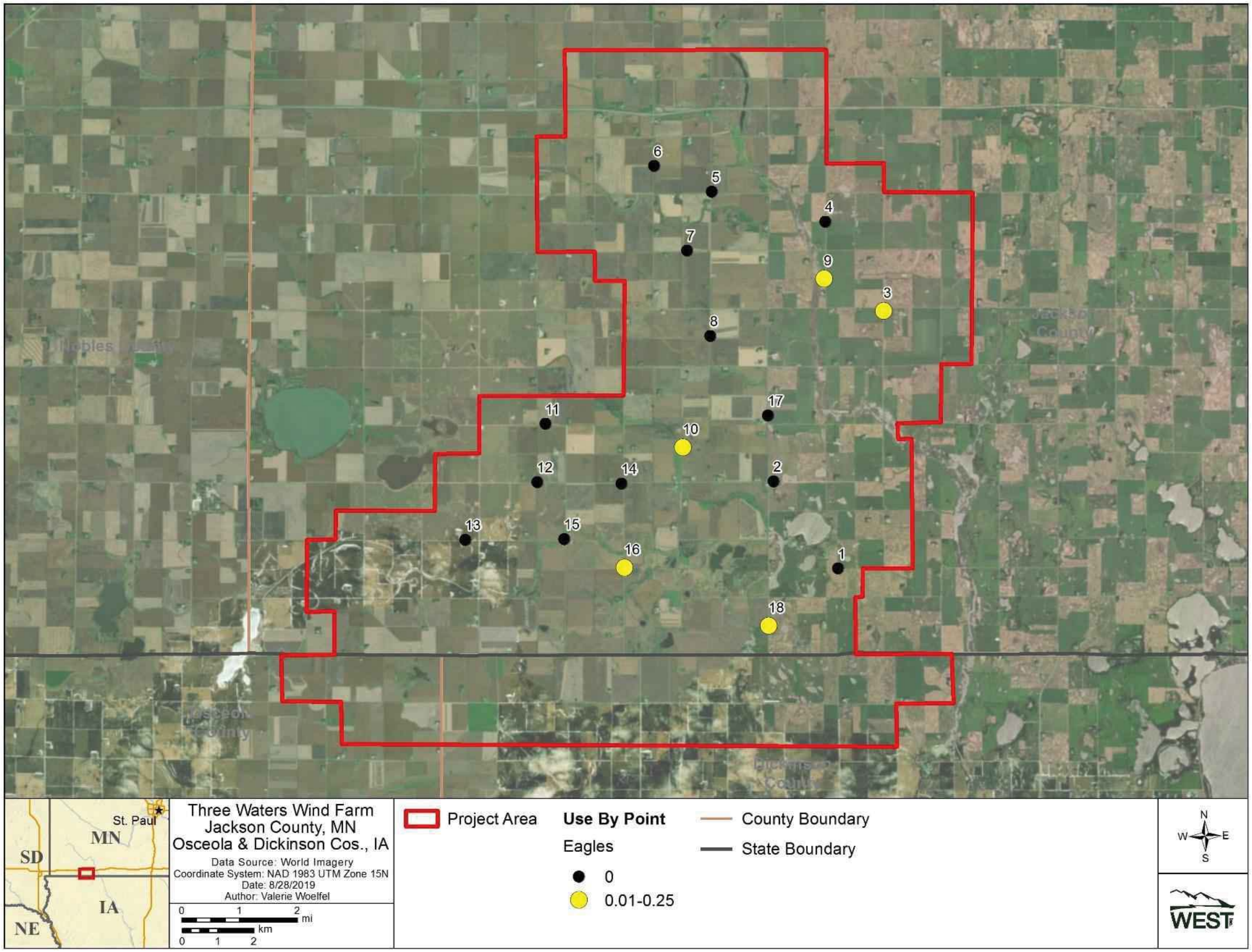

Figure 4. Eagle use by observation point during 60-min fixed-point bird use surveys at the Three Waters Wind Farm from March 24, 2017 – February 18, 2018.

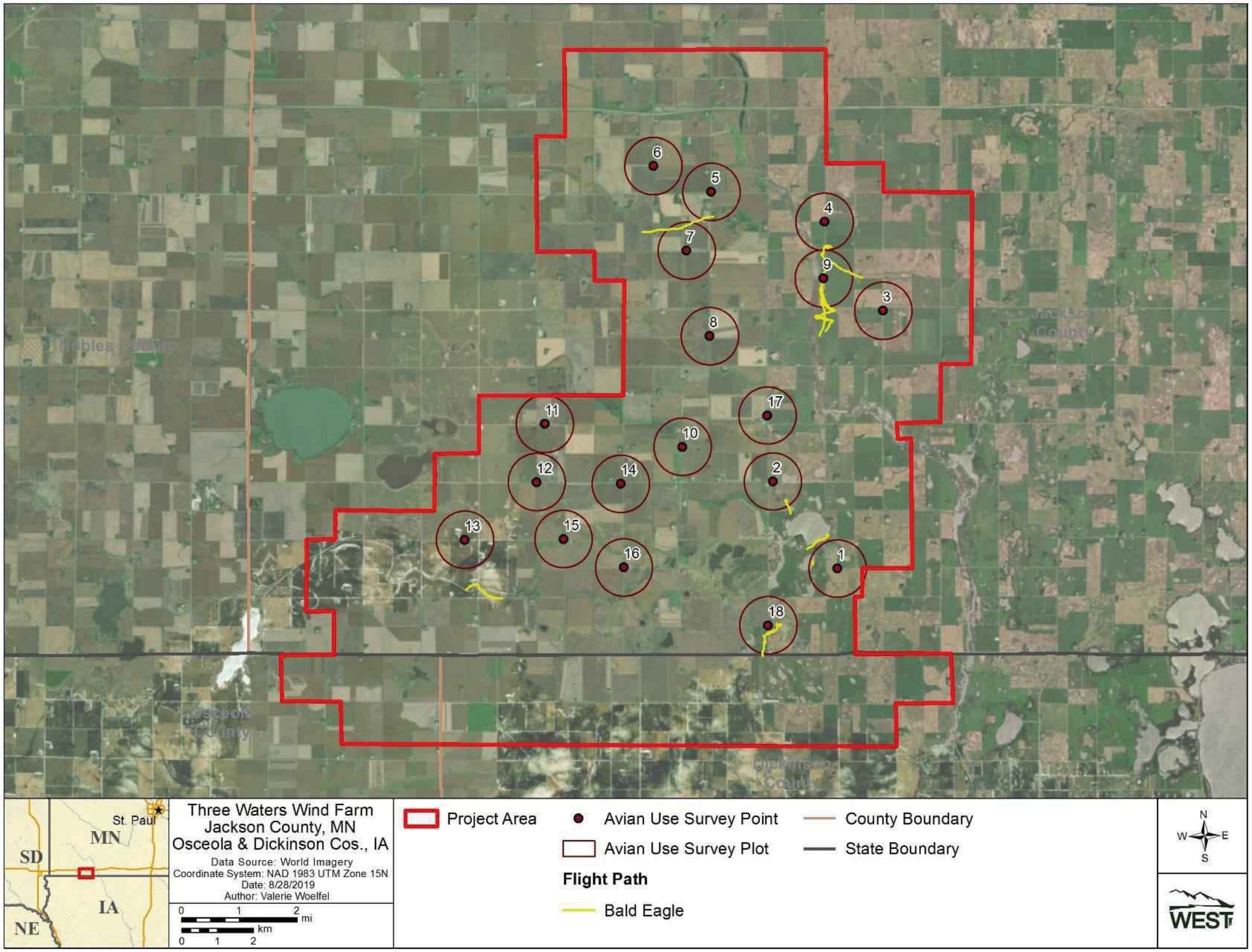

Figure 5. Eagle flight paths recorded during 60-minute fixed-point bird-use surveys within the Three Waters Wind Farm from March 24, 2017 – February 18, 2018.

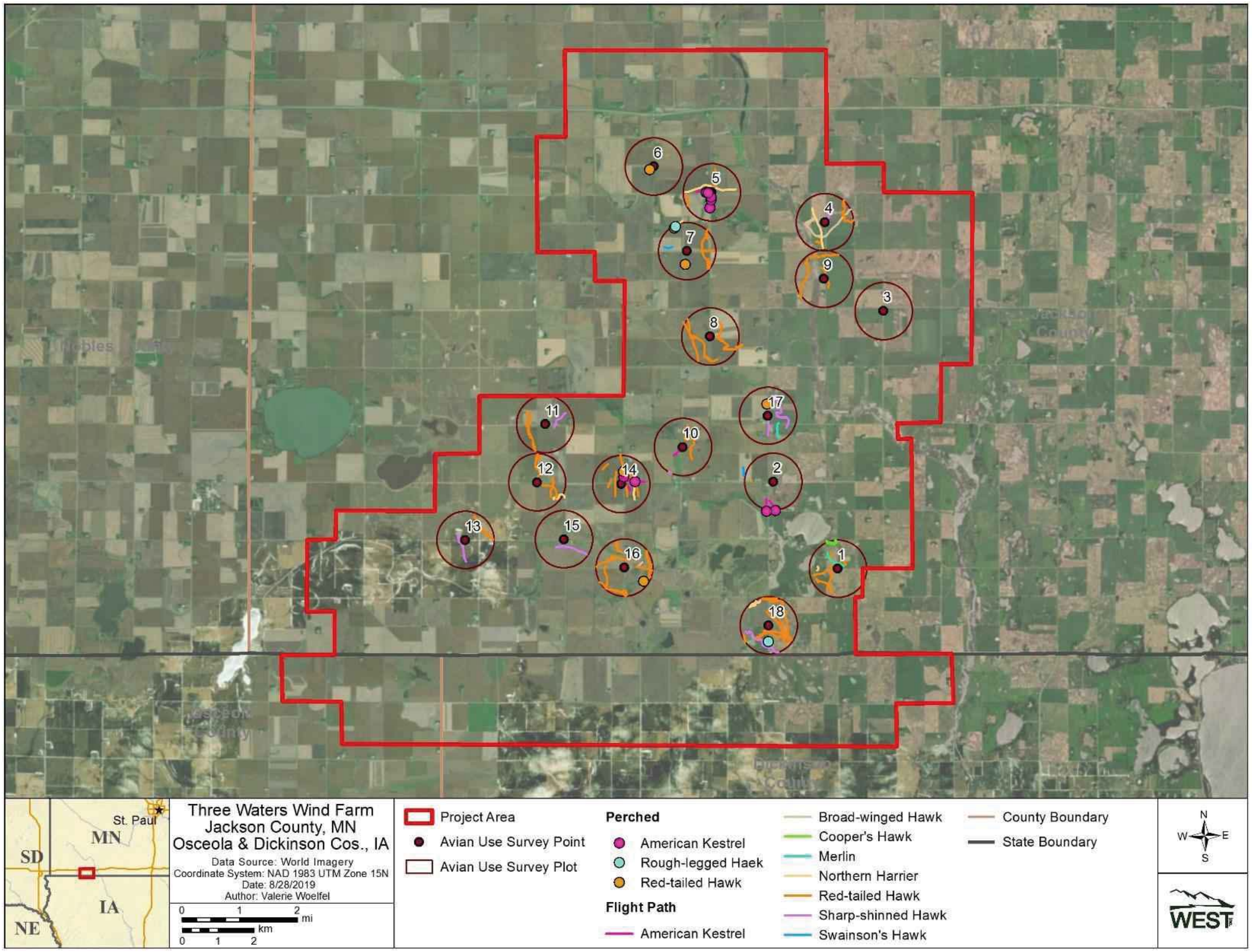

Figure 6. Diurnal raptor flight paths recorded during 60-minute fixed-point bird-use surveys within the Three Waters Wind Farm from March 24, 2017 – February 18, 2018.

6.1.3 Year 2 Results

Two hundred fourteen fixed-point large bird use surveys were conducted from March 3, 2018 – February 27, 2019. Fifty-six large bird species were identified during the large bird use surveys. Species richness was greatest during the spring (50 species) and lowest during the winter (7 species). The index to species richness was highest in spring (4.24 large bird species/800-m plot/60-min survey), followed by summer (2.17 large bird species/800-m plot/60-min survey), fall (1.48 large bird species/800-m plot/60-min survey), and winter (0.38 large bird species/800-m plot/60-min survey).

Sensitive species recorded during year two surveys included 54 bald eagles, 986 American white pelicans, 747 Franklin's gulls, 60 northern pintails, 32 northern harriers, one peregrine falcon, 26 lesser scaup (*Aythya affinis*), seven upland sandpipers (*Bartramia longicauda*), three western grebes (*Aechmophorus occidentalis*), two common loons (*Gavia immer*), one common nighthawk (*Chordeiles minor*), one northern goshawk (*Accipiter gentilis*), one short-eared owl (*Asio flammeus*), one Swainson's hawk, and one Virginia rail (*Rallus limicola*). Incidental observations of sensitive large bird species included 20 American white pelicans, three bald eagles, two northern harriers, two trumpeter swans.

There were 13,869 large bird observations recorded within 1,049 separate groups. Waterfowl were the most abundant large bird type overall (10,078 observations), largely due to the abundance of Canada goose and greater white-fronted goose (*Anser albifrons*) in spring (2,933 and 2,197 observations, respectively). American white pelican was the most abundant large bird species in summer (250 observations). Of the 13 species of diurnal raptor species recorded during surveys, red-tailed hawks were most abundant (83 observations), followed by bald eagle (54 observations) and northern harrier (32 observations).

From the 54 bald eagle observations, 196 total eagle minutes were recorded and 63 eagle minutes were recorded in the Zone of Risk (ZOR). Most eagle minutes in the ZOR were recorded during fall (23 minutes), while fewer were recorded during spring (17 minutes), summer (15 minutes), and winter (8 minutes).

Overall large bird use was highest during spring (139.59 observations/800-m plot/60-min survey), followed by fall (46.04 observations/800-m plot/60-min survey), summer (8.11 observations/800-m plot/60-min survey), and winter (3.55 observations/800-m plot/60-min survey). Waterfowl had the highest use of all large bird types in all seasons, although waterfowl use was higher during spring (129.94 observations/800-m plot/60-min survey) and fall (19.93 observations/800-m plot/60-min survey) compared to summer (2.59 observations/800-m plot/60-min survey) and winter (1.41 observations/800-m plot/60-min survey). Diurnal raptor use occurred in all seasons, but was higher in spring (1.87 observations/800-m plot/60-min survey) and fall (0.63 observations/800-m plot/60-min survey) compared to summer (0.15 observations/800-m plot/60-min survey) and winter (0.12 observations/800-m plot/60-min survey). Bald eagle use was relatively low during all seasons, ranging from 0.06 observations/800-m plot/60-min survey in winter to 0.15 observations/800-m plot/60-min survey in both spring and fall (Figures 7, 8, & 9).

During large bird surveys, 54.0% of all flying large birds were within the RSH when first observed, 8.0% were below the RSH, and 38.0% were above the RSH. Of flying diurnal raptors, 41.6% were within the RSH, 34.3% were below the RSH, and 24.1% were above the RSH. Of the 24 bald eagles observed flying, 79.2% were within the RSH when first observed, 8.3% were below the RSH, and 12.5% were above the RSH (Figure 9).

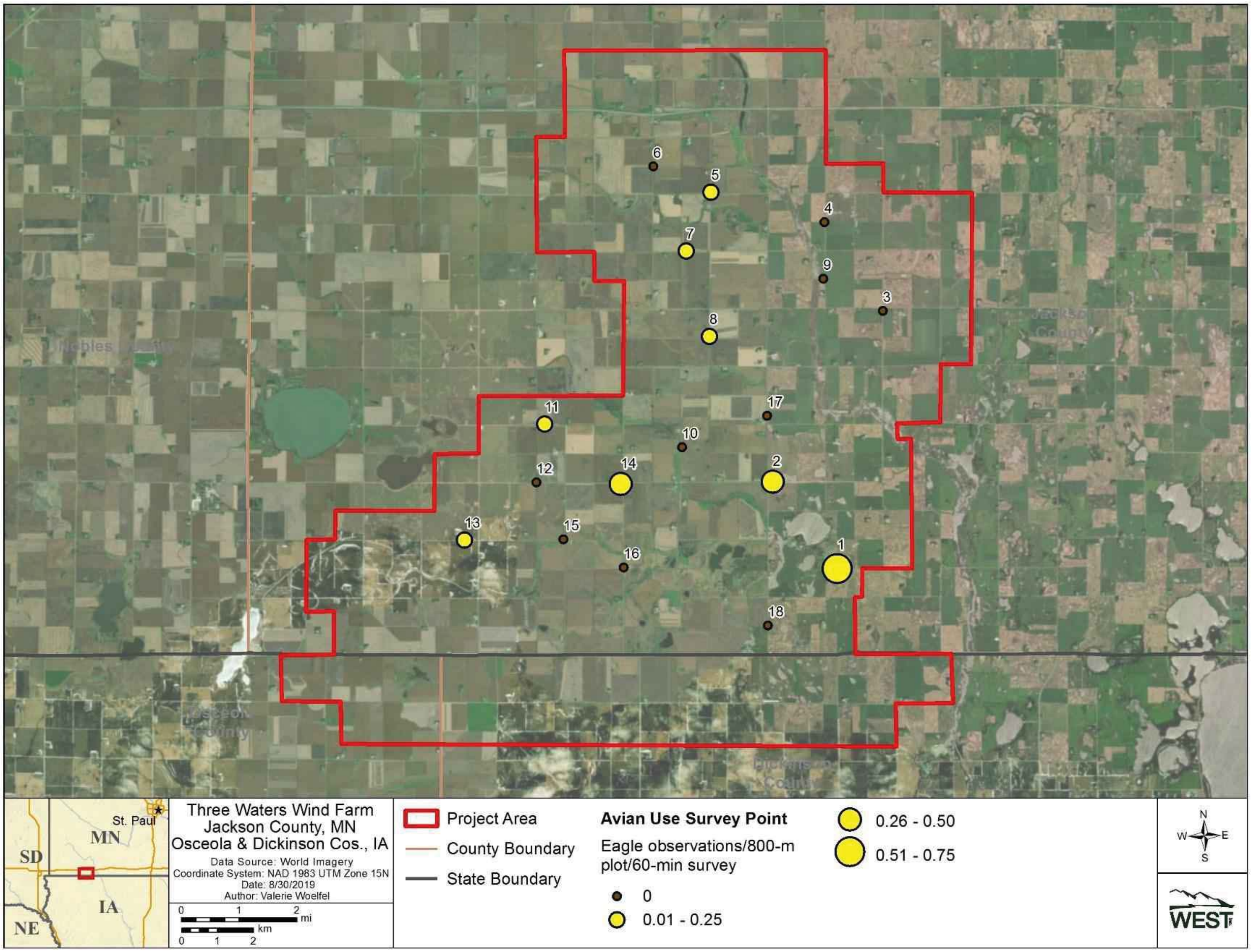

Figure 7. Bald eagle use by observation point during eagle/large bird use surveys conducted from March 3, 2018 – February 27, 2019 at the Three Waters Wind Farm in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

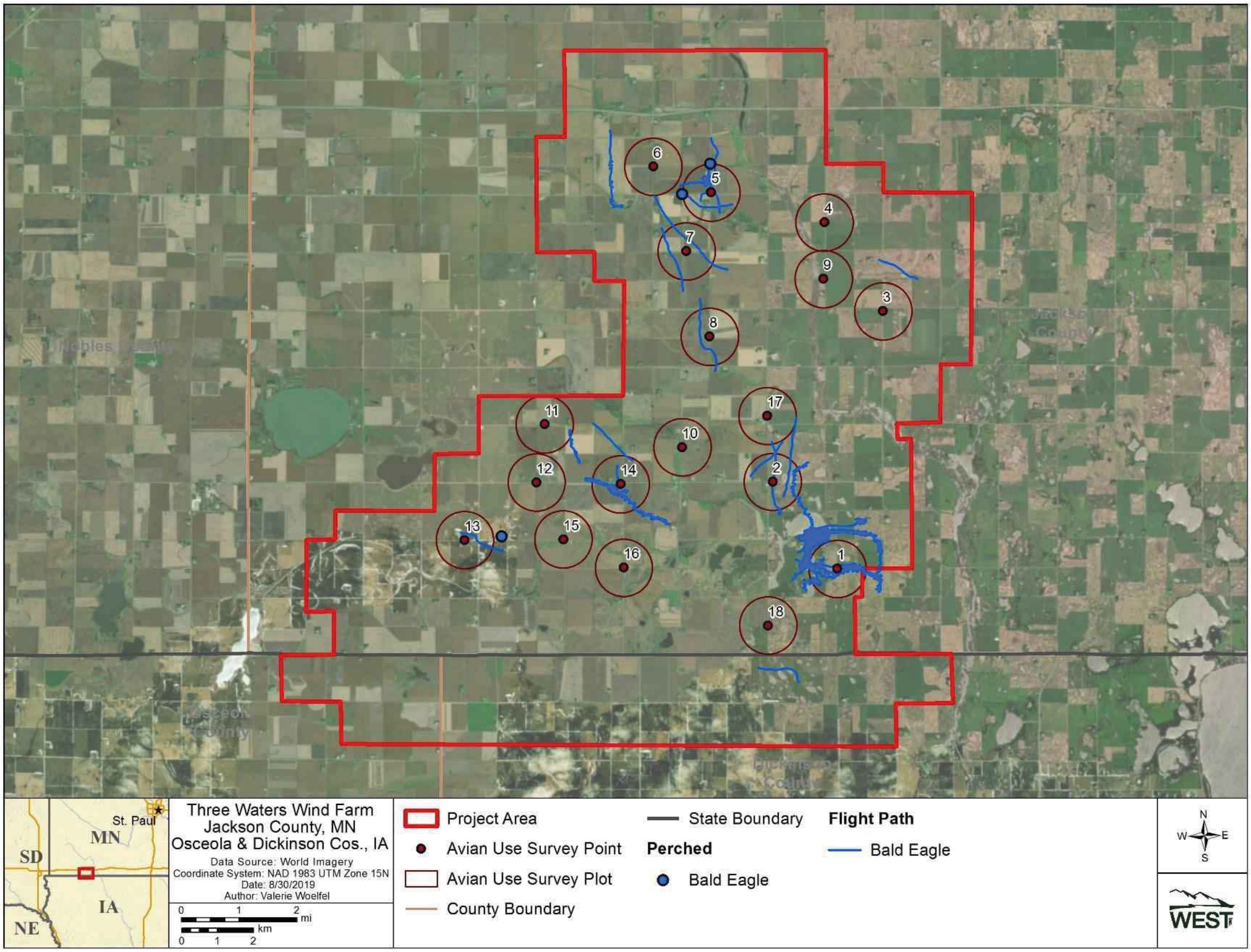

Figure 8. Bald eagle flight paths recorded during eagle/large bird use surveys conducted from March 3, 2018 − February 27, 2019 at the Three Waters Wind Farm in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

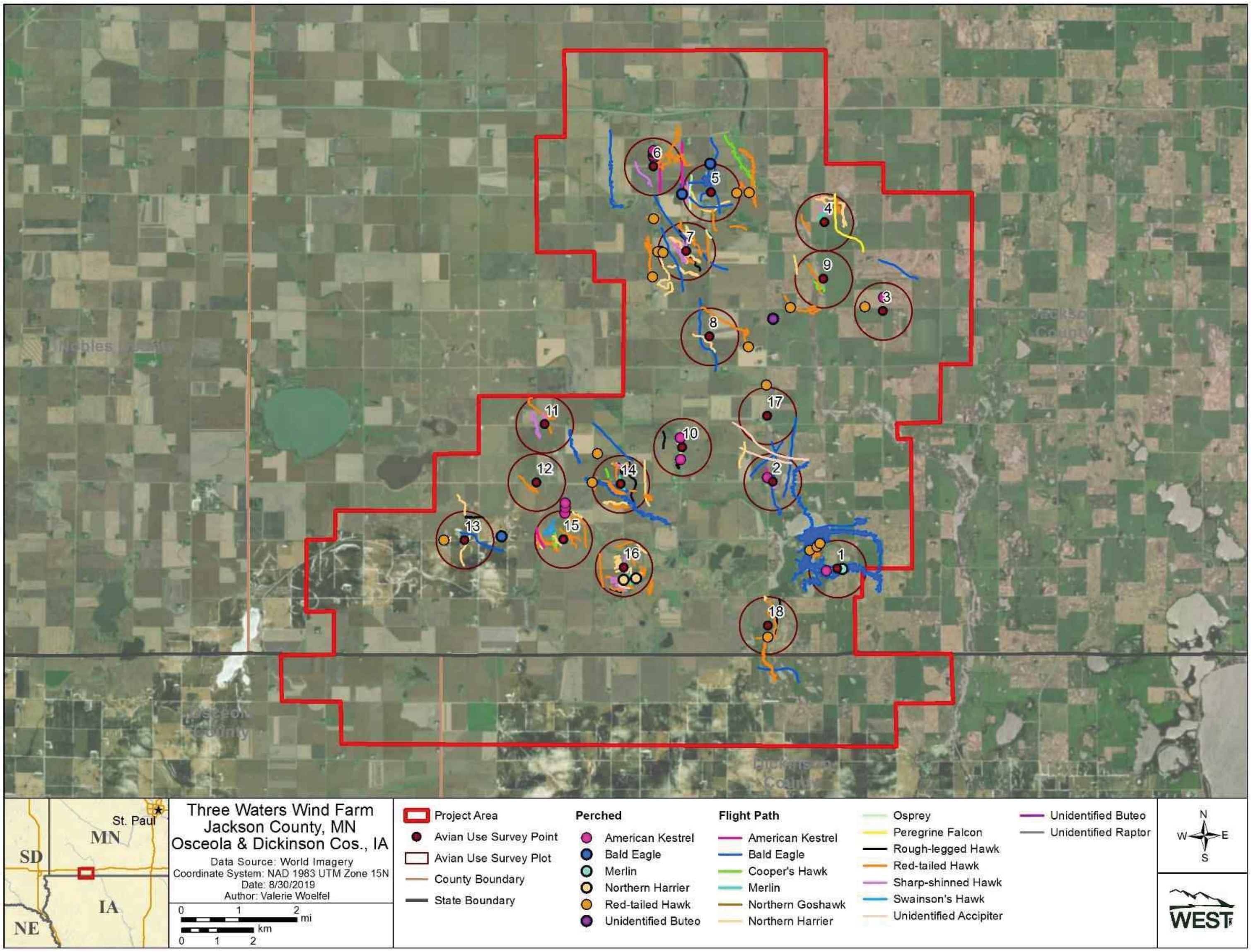

Figure 9. Diurnal raptor flight paths recorded during eagle/large bird use surveys conducted from March 3, 2018 − February 27, 2019 at the Three Waters Wind Farm in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

6.2 2017-2018 Small Bird Use Surveys

6.2.1 Methods

The objective of small bird use surveys was to provide a species list for small birds recorded during surveys and to document relative abundance at the sampling locations. The small bird use surveys consisted of small bird counts at the same 18 observation points used for eagle and other large bird surveys (Figure 3). Small birds were defined as passerines (songbirds excluding large corvids), kingfishers, swifts and hummingbirds, woodpeckers, and cuckoos.

Small bird use surveys were conducted for 10 min preceding the eagle and other large bird surveys at each point. All small birds were recorded, but analyses were restricted to only those within 100 m (328 ft) of the observer. The estimated distance to each bird observed was recorded to the nearest 5-m (16-ft) interval. Other data recorded for each survey included date, start, and end time of the observation period; species or best possible identification; number of individuals; sex and age class, distance from plot center when first observed; closest distance; behavior; flight height above ground; activity; and habitat.

6.2.2 Year 1 Results

Forty-five small bird species were documented during the small bird fixed-point bird use surveys. Small bird species richness was highest in summer (3.35 species/100-m plot/10-min survey), followed by spring (2.31 species/100-m plot/10-min survey), fall (1.30 species/100-m plot/10-min survey), and winter (0.30 species/100-m plot/10-min survey).

Sensitive species recorded during fixed-point small bird surveys included 12 dickcissels (*Spiza americana*), eight bobolinks (*Dolichonyx oryzivorus*), five sedge wrens (*Cistothorus platensis*), two swamp sparrows (*Melospiza georgiana*), two marsh wrens (*Cistothorus palustris*), one eastern meadowlark (*Sturnella magna*), one field sparrow (*Spizella pusilla*), and one state endangered Henslow's sparrow (*Ammodramus henslowii*).

Small bird surveys resulted in 3,036 observations in 525 groups. Passerines made up nearly all of the observations. Red-winged blackbirds (*Agelaius phoeniceus*) were the most abundant small bird species recorded during spring (149 observations), summer (89 observations), and fall (475 observations). Lapland longspurs (*Calcarius lapponicus*) and horned lark (*Eremophila alpestris*) represented most observations during winter (395 and 193 observations, respectively).

Overall small bird use was highest in the fall (29.78 observations/100-m plot/10-min survey), followed by winter (11.11 observations/100-m plot/10-min survey), summer (9.02 observations/100-m plot/10-min survey), and spring (4.06 observations/100-m plot/10-min survey). Small bird use in fall was largely influenced by red-winged blackbirds (8.80 observations/100-m plot/10-min survey) and unidentified blackbirds (15.57 observations/100-m plot/10-min survey).

During small bird surveys, 29.3% of all flying small birds were within the RSH when first observed, 69.1% were below the RSH, and 1.7% were above the RSH. An exposure index based on initial flight height and use estimates was calculated for each species. Lapland longspurs had the highest exposure index value (1.60) of all small birds, followed by unidentified blackbirds (0.59) and snow buntings (0.43). Based on the relative abundance and the relatively higher exposure index of Lapland longspur, this species may have a greater potential for fatalities than other small bird species, including species that occurred more frequently and had relatively higher abundance and use throughout multiple seasons.

6.2.3 Year 2 Results

Thirty-six small bird species were documented during the small bird fixed-point bird use surveys. The index to small bird species richness was highest in the summer (3.11 small bird species/100-m plot/10-min survey), followed by spring (1.94 small bird species/100-m plot/10-min survey), fall (0.69 small bird species/100-m plot/10-min survey), and winter (0.15 small bird species/100-m plot/10-min survey).

Sensitive species recorded during fixed-point small bird surveys included eight dickcissels, six bobolinks, five rusty blackbirds (*Euphagus carolinus*), five swamp sparrows, four grasshopper sparrows (*Ammodramus savannarum*), four sedge wrens, and three marsh wrens (all Species of Greatest Conservation Need).

Small bird surveys resulted in 1,714 observations in 644 groups. Passerines made up nearly all of the observations. Overall, horned larks and red-winged blackbirds were the most abundant small bird species recorded (401 and 398 observations, respectively). Horned larks were the most abundant small bird species recorded during spring (360 observations). Common grackles were the most abundant small bird species recorded during summer (159 observations). Red-winged blackbirds were the most abundant small bird species recorded during fall (113 observations). House sparrows (*Passer domesticus*) were the most abundant small bird species recorded during winter (35 observations).

Overall small bird use was highest in the spring (17.57 observations/100-m plot/10-min survey), followed by summer (8.63 observations/100-m plot/10-min survey), fall (4.15 observations/100-m plot/10-min survey), and winter (1.03 observations/100-m plot/10-min survey). High small bird use during the spring was largely influenced by horned lark use (6.67 observations/100-m plot/10-min survey), red-winged blackbird use (3.87 observations/100-m plot/10-min survey), and unidentified blackbird use (2.87 observations/100-m plot/10-min survey).

During year two small bird use surveys, 15.9% of flying small birds were within the RSH when first observed, 52.5% were below the RSH, and 31.6% were above the RSH. An exposure index, based on initial flight height and use estimates, was calculated for each species. Horned larks had the highest exposure index value (0.59) of all small birds, followed by unidentified blackbirds (0.14) and common grackle (0.07).

6.3 Aerial Raptor Nest Surveys

6.3.1 Methods

WEST conducted two separate aerial helicopter eagle and other raptor nest surveys in 2017, with the first conducted from March 29 – April 1 and a follow-up survey conducted on May 3. The surveys included a 1.6-km (1.0-mi) buffer around proposed turbine locations for all raptor nests and a 16-km (10-mi) buffer around proposed turbine locations for eagle nests (Figure 7). During the second survey round, potential eagle nesting habitat within the 16-km (10-mi) buffer was revisited to ensure that no eagle nests were missed during the first round.

WEST conducted a second year of aerial nest surveys on April 9 – 10, 2018, focusing on locating bald eagle nests within a slightly larger survey area (Figure 8) than surveyed in 2017. On May 15, 2018, WEST conducted a follow-up aerial survey of bald eagle nests documented in the first nest survey to confirm species, occupancy, and activity status. The follow-up nest checks occurred 33 to 35 days after the initial survey, following ECPG recommendations that eagle nest status be checked at least 30 days after the initial observation.

Nest status definitions were consistent with the ECPG and nests were classified as occupied, unoccupied, or unknown. To determine the status of a nest, the biologist evaluated behavior of adults on or near the nest, and presence of eggs, young, whitewash, or fresh building materials. Nest condition was categorized as excellent, fair, or poor. Nests were classified as occupied based on five characteristics defined by Postupalsky (1974) and the ECPG (Appendix C). High resolution photographs were taken of each eagle nest or potential eagle nest (see Appendix C). The reported nest status reflects the most active status observed during the aerial survey or follow-up status check.

6.3.2 2017 Results

Twenty-seven raptor nests were located in 2017, including eight occupied and active bald eagle nests and one occupied and inactive bald eagle nest. Two nests (6 and 9) were inactive nests of unidentified species that appeared consistent with the size and shape of a bald eagle nest (Figure 7). Other nests found included seven occupied and active red-tailed hawk nests, three occupied and active great horned owl (*Bubo virginianus*) nests, and one unoccupied great blue heron rookery (Figure 7).

6.3.3 2018 Results

Sixteen raptor nests were located in 2018, including eight occupied and active bald eagle nests and one occupied and inactive bald eagle nest. Two nests (3271 and 3288) were inactive nests of unidentified species that appeared consistent in size and shape of a bald eagle nest (Figure 8). Other raptor nests included two occupied and active great horned owl nests and three occupied active red-tailed hawk nests (Figure 8).

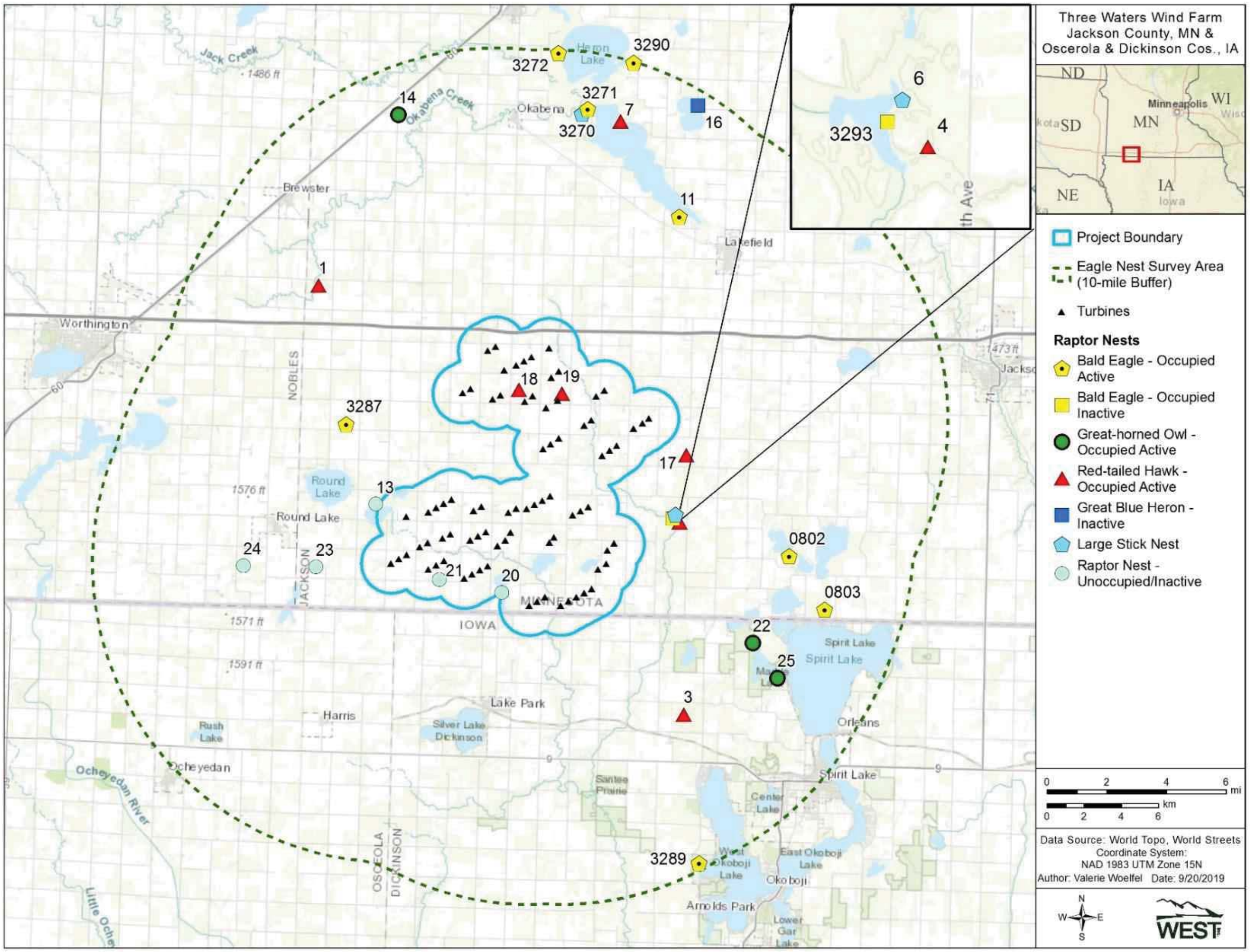

Figure 10. Raptor nests found during aerial surveys conducted in 2017 for the Three Waters Wind Farm in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

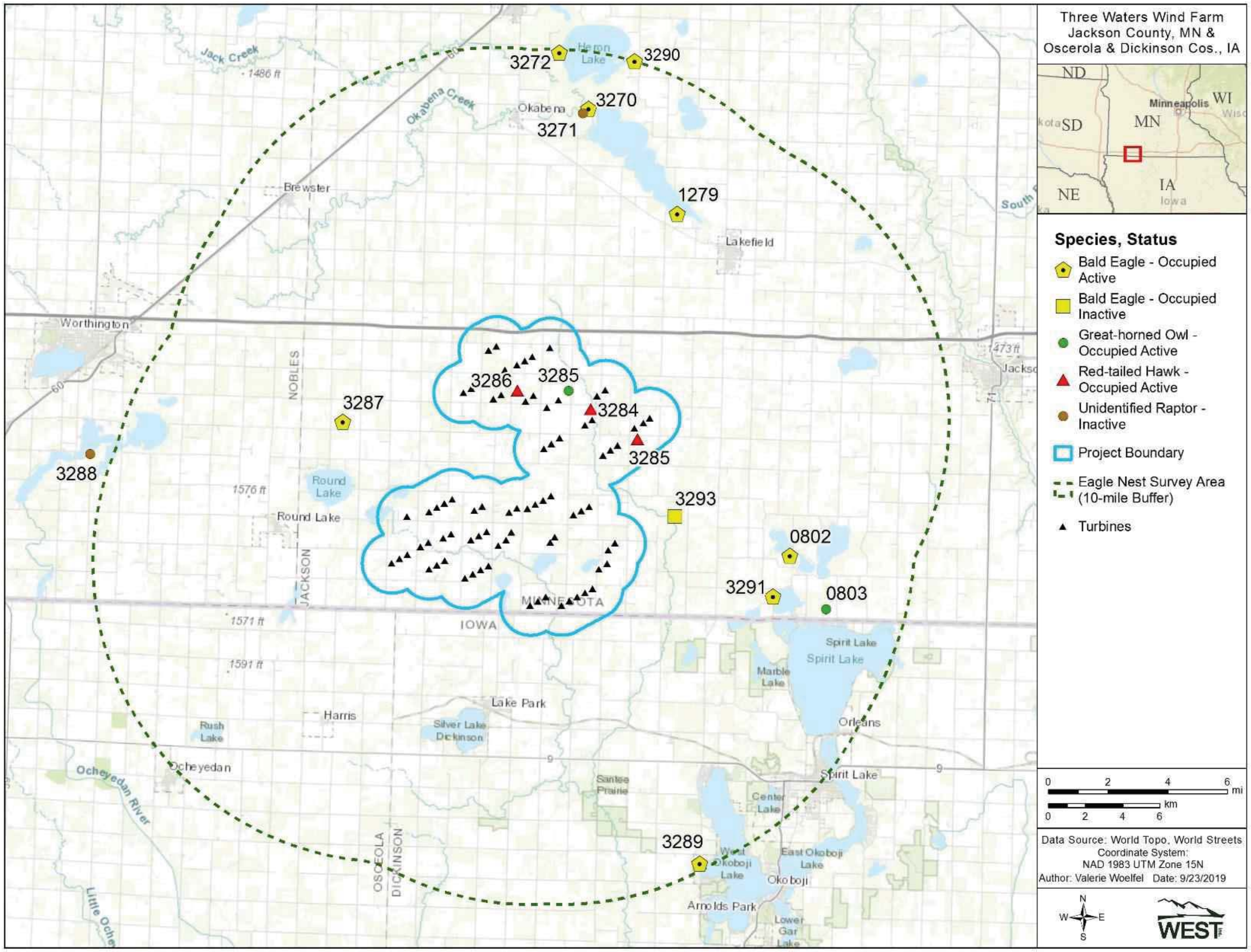

Figure 11. Raptor nests found during aerial surveys conducted in 2018 for the Three Waters Wind Farm in Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

6.4 Bat Acoustic Surveys

6.4.1 Methods

Bat acoustic surveys were conducted to estimate levels of bat activity within the Project area in 2017 and 2018. Acoustic surveys were conducted using AnaBat™ SD2 detectors at five ground stations and one raised station. Ground units were placed approximately 1.5 m (5.0 ft) AGL at all stations in 2017. Station TW1 was considered a fixed station, as the detector remained at this site throughout the entirety of the survey duration. Stations TW2t, TW3t, TW4t, and TW5t were considered temporary stations, as they were moved every two weeks to improve spatial coverage of the Project area (Figure 9). In the surveys in 2018, a raised microphone was placed at TW1 (fixed station) along with a ground unit that remained throughout the study (Figure 10). The raised microphone was placed approximately 45 m (148 ft) AGL on a meteorological tower.

Acoustic detectors at TW1, TW3t, and TW5t were placed in cultivated cropland or other habitat representative of likely turbine locations. Stations TW2t and TW4t were placed near habitats or features that may attract foraging bats such as woodlands and waterbodies (call. Detectors were programmed to turn on nightly at least 30 minutes before sunset and to turn off at least 30 minutes after sunrise. The acoustic surveys were conducted from July 6 through November 11, 2017 and from April 23 to October 15, 2018. To document seasonal activity patterns, data were analyzed separately for two survey periods in 2017: summer (July 6 – August 15) and fall (August 16 – November 11) and three survey periods in 2018: spring (April 23 – May 14), summer (May 15 – August 15), and fall (August 16 – October 15). Mean bat activity was also calculated for the fall migration period, defined as July 30 – October 14.

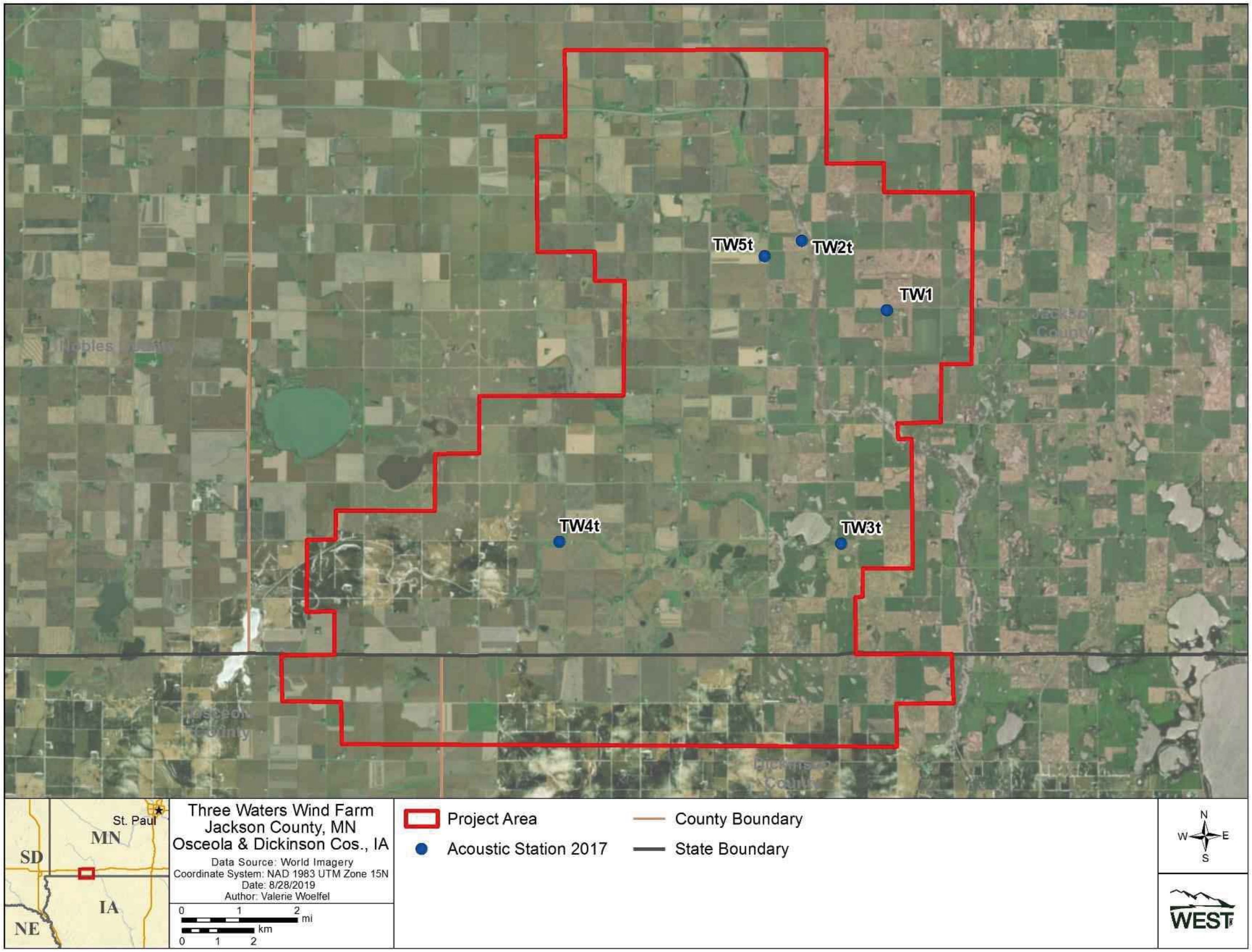

Figure 12. Location of stations used during 2017 bat acoustic surveys at the Three Waters Wind Farm, Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

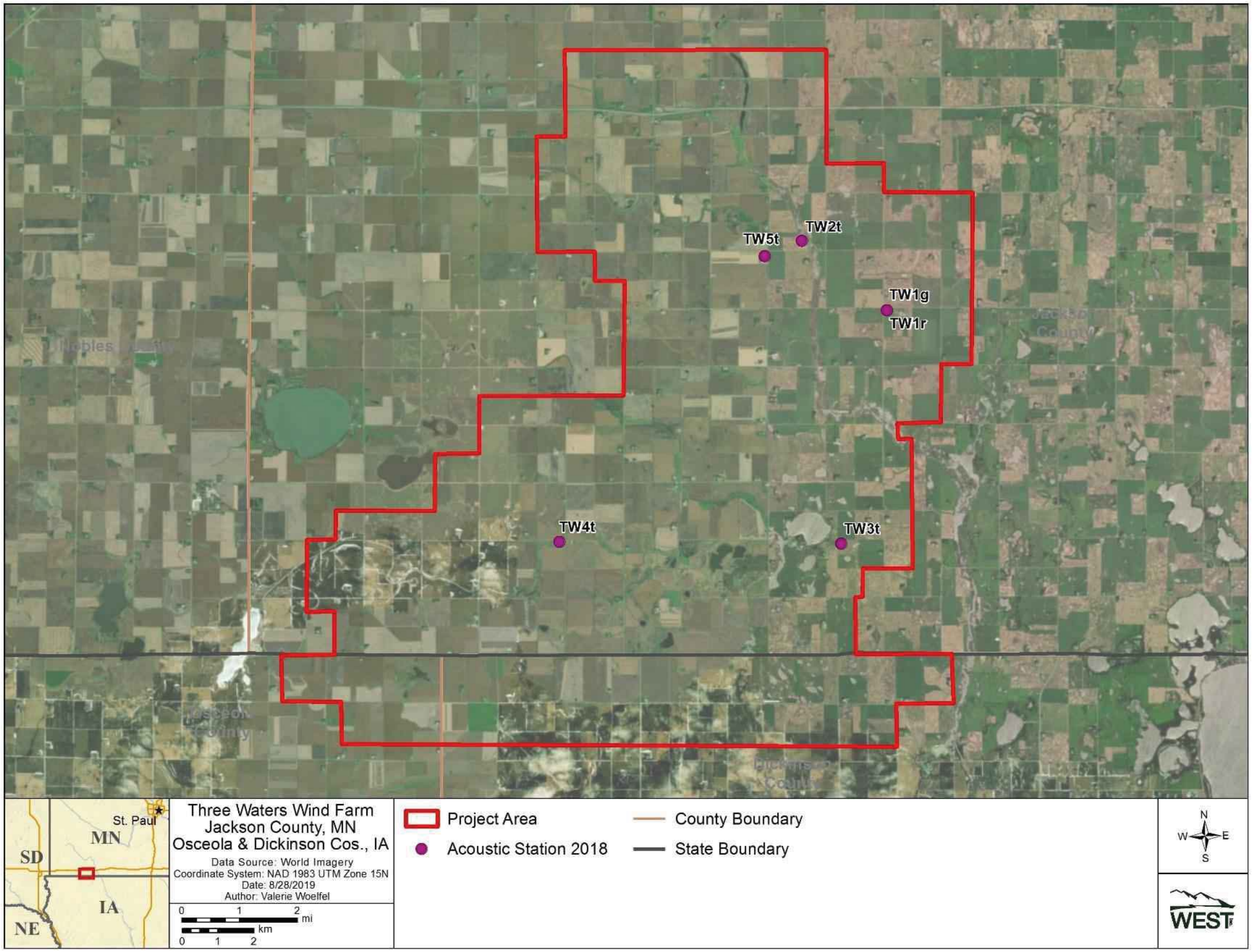

Figure 13. Location of stations used during 2018 bat acoustic surveys at the Three Waters Wind Farm, Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

6.4.2 2017 Results

Anabat units operated for 276 detector nights between July 6 and November 11, 2017. The average bat pass rate was 3.62 ± 0.6 bat passes per detector night (Table 6; Appendix E). Bat activity in the Project area was relatively low and the average bat pass rates were similar between the fixed station (3.72 bat passes per detector-night) and the temporary stations (3.59 bat passes per detector-night; Table 6). However, bat activity was higher at TW3t (11.74 bat passes per detector-night) than the other temporary stations, which ranged from approximately 0.81 – 0.98 bat passes per detector-night (Table 6). Average bat activity was higher during the summer (early to mid-August) than the fall (Figure 10). Most bat calls recorded were low-frequency (e.g., big brown bat [*Eptesicus fuscus*], hoary bat [*Lasiurus cinereus*], and silver-haired bat [*Lasionycteris noctivagans*]). High-frequency bat calls (e.g., *Myotis* species and eastern red bat [*Lasiurus borealis*]) were less common, but followed a similar temporal pattern (Figure 10; Appendix E).

6.4.3 2018 Results

Anabat units operated for 670 detector nights between April 23 and October 15, 2018. The average bat pass rate was 14.61 ± 1.39 bat passes per detector night (Table 7; Appendix F). Activity at the fixed station was relatively low and similar between the ground (1.64 bat passes per detector-night) and raised (1.39 bat passes per detector-night) microphones (Table 7). Activity at temporary stations varied, ranging from 7.07 bat passes per detector-night at station TW3t to 36.57 bat passes per detector-night at station TW5t (Table 7). Bat activity during fall migration at ground-based stations was 2.09 ± 0.31 (mean ± standard error) bat passes per detector night (Table 7). Average bat activity was higher during the summer (mid to late August) than in the fall (Figure 11). Most bat calls recorded were low-frequency, while high-frequency bat calls were less common, but followed a similar temporal pattern (Figure 11; Appendix F).

Table 6. Results of acoustic bat surveys conducted at the Three Waters Wind Farm from July 6 to November 11, 2017.

				Bat Passes			Detector-	Bat Passes/Detector-night
Station	**Type**	**Location**	**Habitat**	**HF**	**LF**	**Total**	**nights**	**(± Standard Error)***
TW1	fixed	ground	representative	161	230	391	105	3.72 ± 0.45
TW2t	temporary	ground	feature	3	32	35	41	0.85 ± 0.85
TW3t	temporary	ground	representative	125	368	493	42	11.74 ± 2.41
TW4t	temporary	ground	representative	7	32	39	40	0.98 ± 0.31
TW5t	temporary	ground	feature	10	29	39	48	0.81 ± 0.91
Total				**306**	**691**	**997**	**276**	**3.62 ± 0.60**

* Bootstrapped standard error

HF = high frequency; LF = low frequency

Table 7. Results of acoustic bat surveys conducted at the Three Waters Wind Farm from April 23 to October 15, 2018.

				Bat Passes			Detector-	Bat Passes/Detector-night
Station	**Type**	**Location**	**Habitat**	**HF**	**LF**	**Total**	**nights**	**(± Standard Error)***
TW1	fixed	ground	representative	47	241	288	176	1.64 ± 0.16
TW1	fixed	raised	representative	26	211	237	171	1.39 ± 0.24
TW2t	temporary	ground	feature	52	1,400	1,452	70	20.74 ± 4.41
TW3t	temporary	ground	representative	72	508	580	82	7.07 ± 0.68
TW4t	temporary	ground	representative	32	1,629	1,661	82	20.26 ± 5.03
TW5t	temporary	ground	feature	1,040	2,215	3,255	89	36.57 ± 4.52
Total				**1,269**	**6,204**	**7,473**	**670**	**14.61 ± 1.39**

* Bootstrapped standard error

HF = high frequency; LF = low frequency

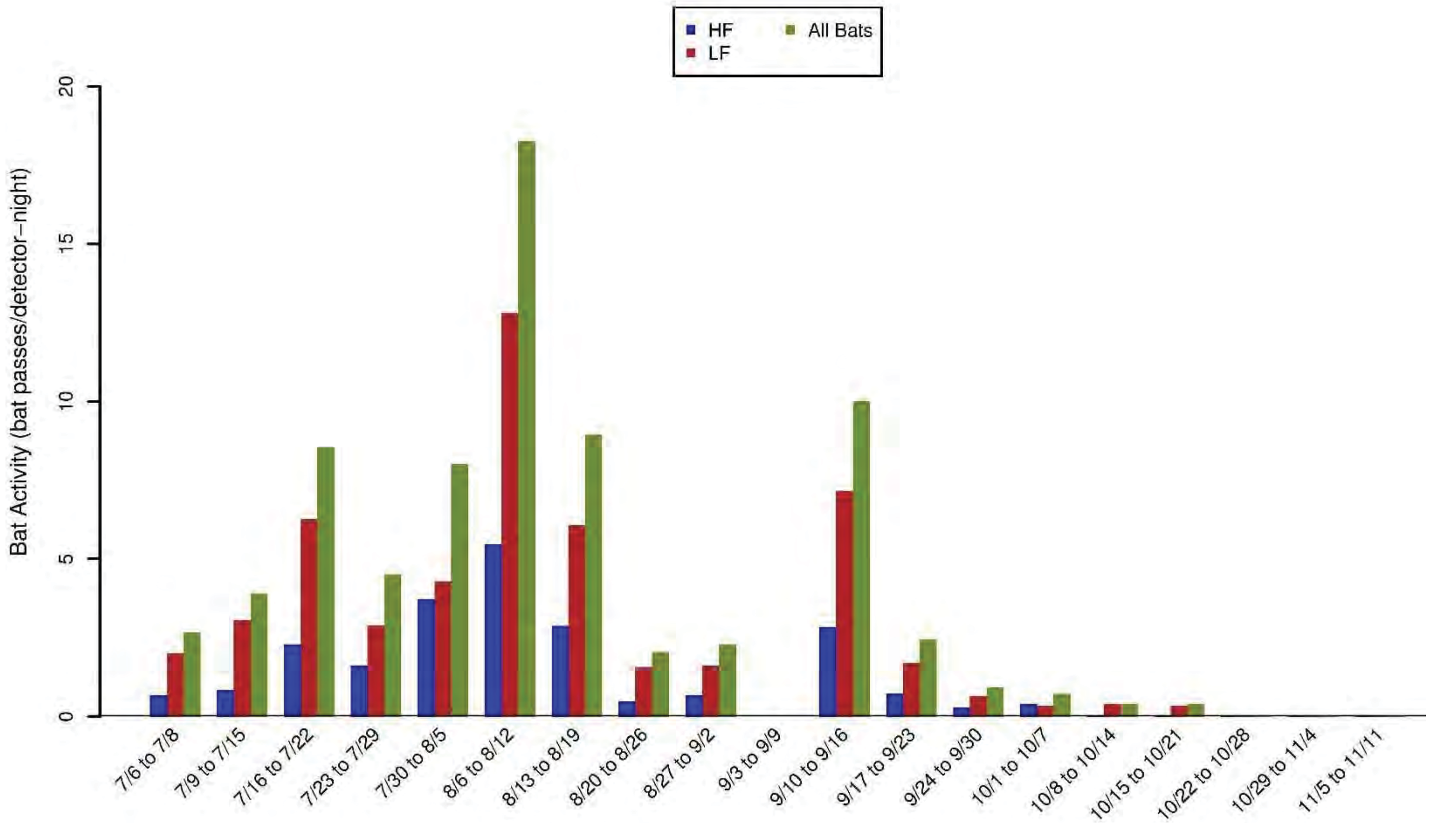

Figure 14. Weekly patterns of bat activity (bat passes) by high-frequency (HF), low-frequency (LF), and all bats at representative monitoring stations within the Three Waters Wind Farm, July 6 – November 11, 2017.

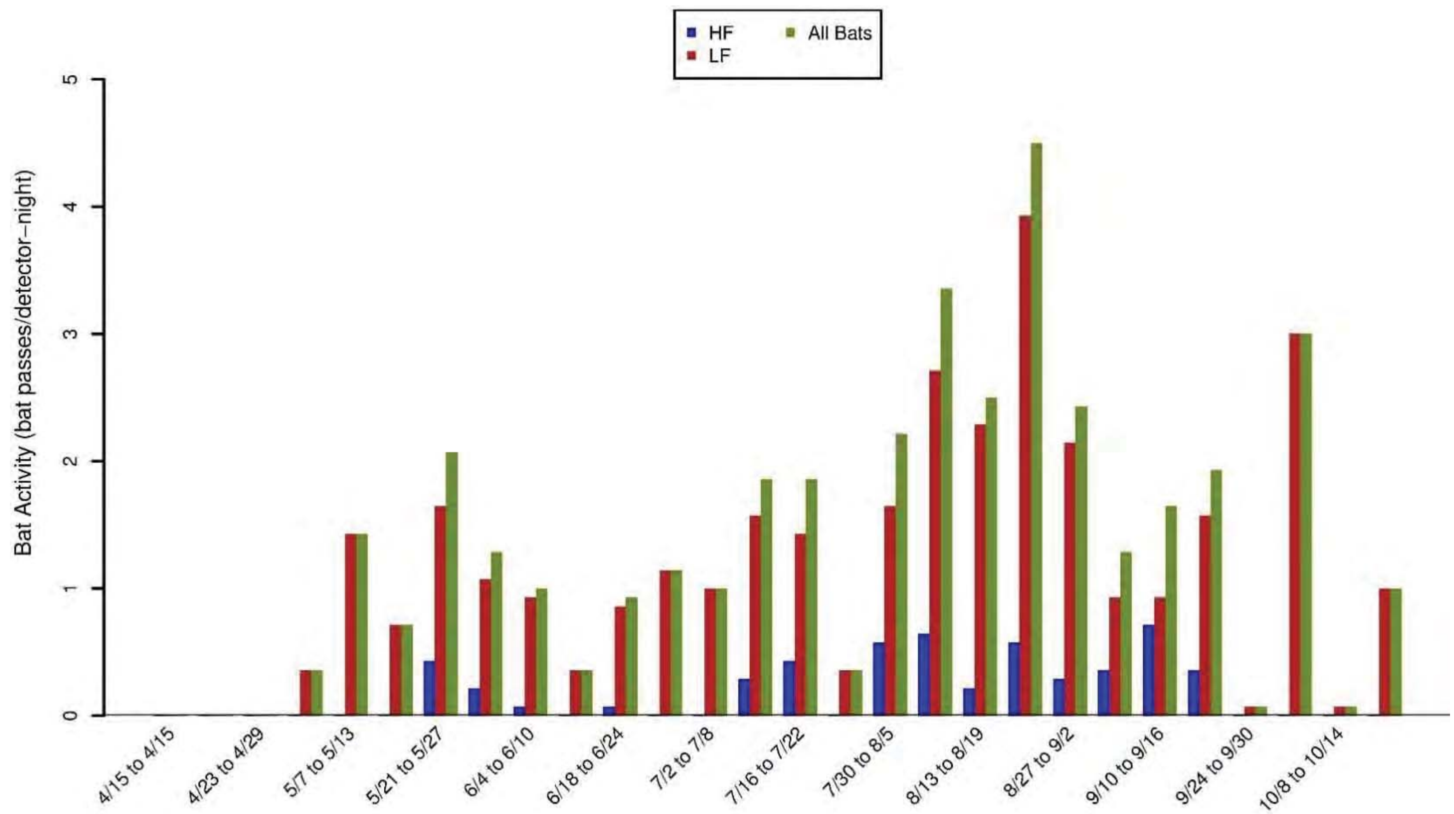

Figure 15. Weekly patterns of bat activity (bat passes) by high-frequency (HF), low-frequency (LF), and all bats at representative monitoring stations within the Three Waters Wind Farm, April 23 – October 15, 2018.

6.5 2017 Northern Long-eared Bat Acoustic Surveys

6.5.1 Methods

Acoustic surveys were conducted to target the federally threatened northern long-eared bat (*Myotis septentrionalis*; NLEB) at four sites within the Project area from June 17–20, 2017, adhering to USFWS guidelines (USFWS 2014, 2017; Figure 12). Surveys were conducted using SM4BAT™ ultrasonic detectors (Wildlife Acoustics, Inc., Maynard, MA). Detectors were placed in habitats suitable for northern long-eared bats, including forest edges, small clearings and forest-canopy openings, near water sources and/or forested riparian edges. Detectors were placed in areas with open tree canopies or canopy heights greater than 33 ft (10 m) and were spaced at least 656 ft (200 m) apart. Detectors were elevated at least 10 ft (3 m) above ground level (AGL). Acoustic monitoring began before sunset and continued throughout the night. Survey duration at each site was a minimum of four detector nights (i.e., two detectors for two nights). Bat calls were quantitatively identified using Kaleidoscope (version 4.2.0; Bats of North America classifier version 4.2.0; Wildlife Acoustics). All calls identified as NLEB by automated ID software were verified via qualitative call analysis.

6.5.2 Results

The number of bat calls per detector night ranged from 27 to 394 bat calls per detector night, with an average of 61.2 bat calls per detector night within the Project (Table 8; Appendix G). Kaleidoscope identified 1,468 bat call files and identified 1,324 files to species (Table 8). Automated acoustic ID software identified potential NLEB calls at 4 sites (sites TW-1a, TW-2a, TW-3b, and TW-4a), but qualitative analysis determined the calls were not NLEB. Based on these results, NLEB is considered to be likely absent from the Project area. No follow-up mist-netting was required due to the lack of positive NLEB calls.

Table 8. Species identified by Kaleidoscope during 2017 northern long-eared bat surveys at the Three Waters Wind Farm.

Site ID	EPFU	LABO	LACI	LANO	MYLU	NLEB	PESU	UNK	Total
TW-1a	135	80	3	0	13	1	2	25	**259**
TW-1b	169	129	2	5	2	0	7	13	**327**
TW-2a	36	0	167	11	2	1	0	23	**240**
TW-2b	272	0	41	24	5	0	0	52	**394**
TW-3a	5	52	11	0	1	0	1	8	**78**
TW-3b	28	18	9	2	3	1	2	4	**67**
TW-4a	24	21	8	0	9	2	0	12	**76**
TW-4b	5	7	5	2	1	0	0	7	**27**
Totals	**674**	**307**	**246**	**44**	**36**	**5**	**12**	**144**	**1,468**

EPFU = Big Brown Bat, LABO = Eastern Red Bat, LACI = Hoary Bat, LANO = Silver-haired Bat, MYLU = Little Brown Bat, NLEB = Northern Long-eared Bat, PESU = Tri-colored Bat, UNK = Unknown.

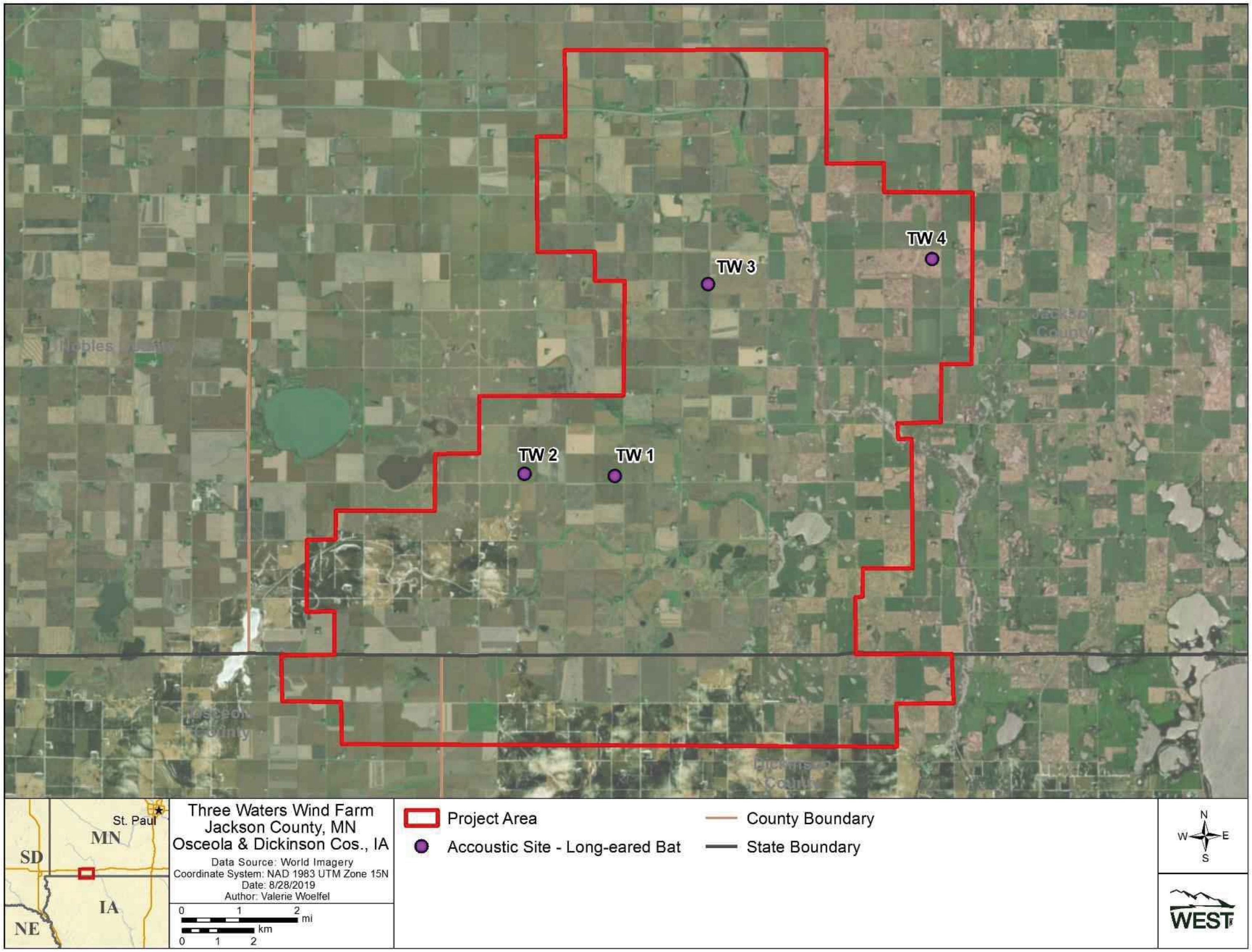

Figure 16. Location of stations used during northern long-eared bat acoustic surveys at the Three Waters Wind Farm, Jackson County, Minnesota and Dickinson and Osceola counties, Iowa.

7 ASSESSMENT OF RISKS TO BIRDS AND BATS

Impacts to birds and bats may include direct impacts (i.e., collision mortality) or indirect impacts (e.g., habitat loss, fragmentation, disturbance, or displacement). Data from site-specific and regional pre-construction surveys, along with publicly available information from comparable wind energy projects, were used to assess risk to birds and bats at the Project.

7.1 Mortality Risk Assessment

7.1.1 Birds

Mortality risk to birds is largely related to collision with wind turbines. Estimates of annual bird mortality caused by wind turbines in the US range from 368,000 (Erickson et al. 2014) to 679,089 (Smallwood 2013). In the US, wind turbines are estimated to cause 0.02 percent of anthropogenic avian mortalities (Table 9). Furthermore, the number of avian mortalities at wind energy facilities is low compared to the total number of birds observed at these sites (Erickson et al. 2002b). Limited data from existing wind energy facilities suggest that about half of mortalities are migratory birds and half are resident birds (NRC 2007). In addition to mortality from collision with wind turbines, Project construction can cause mortality of birds and other wildlife due to destruction of nests, eggs, or young, as well as collisions with vehicles and construction equipment. Collision with various man-made structures can be a significant source of bird mortality (Table 9).

Table 9. Estimated annual avian mortality from anthropogenic causes in the United States (from Loss et al. 2015).

Mortality Source	Estimated Annual Mortality	Percent	Reference
Cats	2,407,000,000	74.26	Loss et al. 2013a
Buildings	599,000,000	18.48	Loss et al. 2014a
Automobiles	199,600,000	6.16	Loss et al. 2014b
Power Line Collisions	22,800,000	0.70	Loss et al. 2014c
Communication towers	6,581,945	0.20	Longcore et al. 2012
Power Line Electrocutions	5,630,000	0.17	Loss et al. 2014c
Wind Turbines	573,093	0.02	Smallwood 2013

7.1.1.1 Diurnal Raptors

Diurnal raptors are known to be susceptible to collision with wind turbines, although collision risk may vary geographically and seems to be higher in the western US (NRC 2007). Several species of diurnal raptors occur in the Project area, at least during part of the year. Overall, diurnal raptor use at the Project was low compared to 46 publicly available studies (Figure 13). Three wind-energy facilities in Minnesota have publicly available mortality data for comparison (Table 10). Based on results from two years of avian use surveys, diurnal raptor fatality rates at the Project are expected to be low.

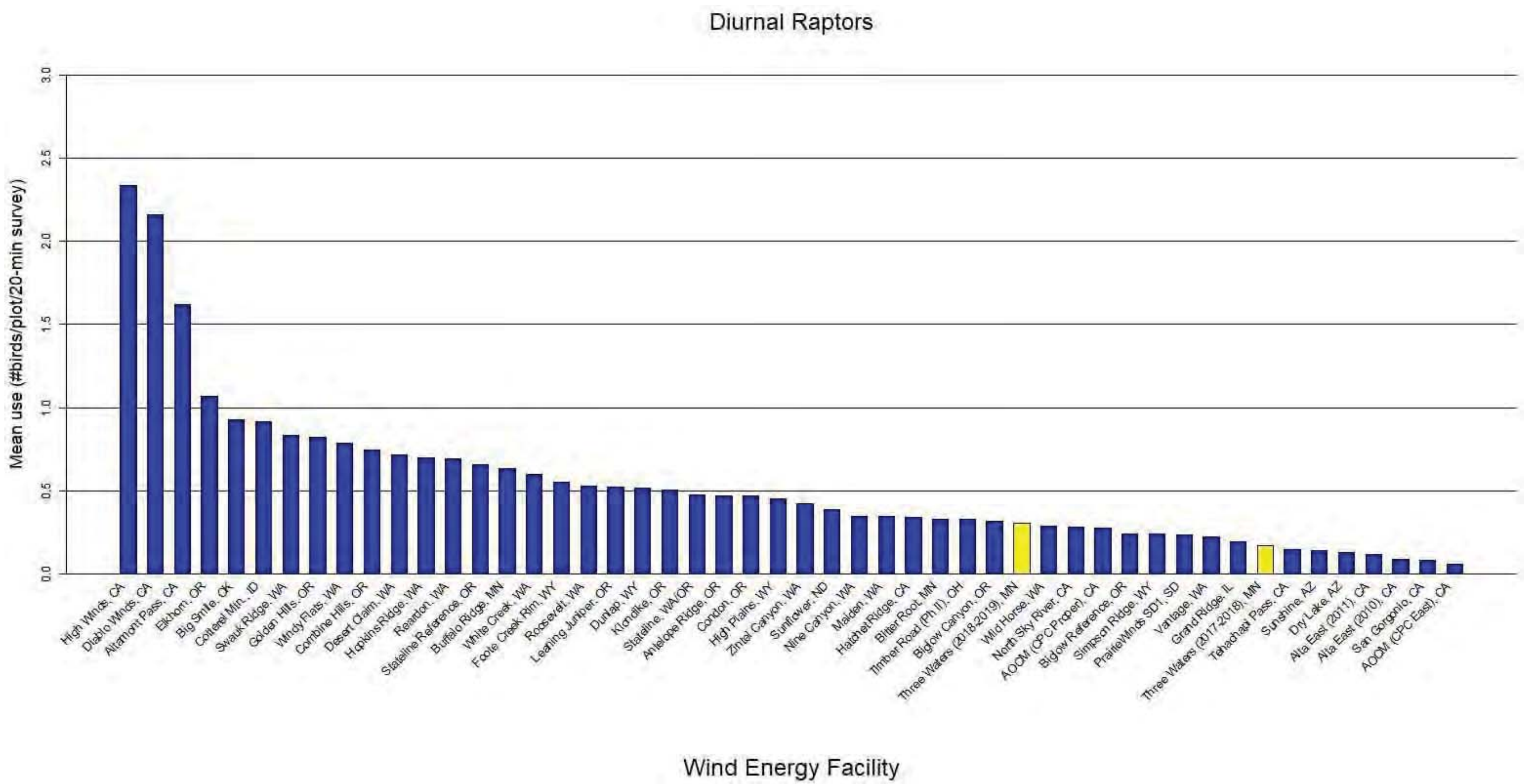

Figure 17. Comparison of estimated annual diurnal raptor use during fixed-point bird use surveys at the Three Waters Wind Farm and diurnal raptor use at other US wind energy facilities with three or four other seasons of raptor use data.

Figure 17 (*continued*). Comparison of estimated annual diurnal raptor use during fixed-point bird use surveys at the Three Waters Wind Farm and diurnal raptor use at other US wind resource areas with three or four other seasons of raptor use data.

Data from the following sources:

Wind Energy Facility	Reference	Wind Energy Facility	Reference
Three Waters (2018-19)	Baird et al. 2019		
High Winds, CA	Kerlinger et al. 2005	High Plains, WY	Johnson et al. 2009b
Diablo Winds, CA	WEST 2006	Zintel Canyon, WA	Erickson et al. 2002a, 2003c
Altamont Pass, CA	Orloff and Flannery 1992	Sunflower, ND	Derby and Thorn 2014
Elkhorn, OR	WEST 2005b	Nine Canyon, WA	Erickson et al. 2001
Big Smile (Dempsey), OK	Derby et al. 2010a	Maiden, WA	Young et al. 2002
Cotterel Mtn., ID	Bureau of Land Management 2006	Hatchet Ridge, CA	Young et al. 2007a
Swauk Ridge, WA	Erickson et al. 2003b	Bitter Root. MN	Derby and Dahl 2009
Golden Hills, OR	Jeffrey et al. 2008	Timber Road (Phase II), OH	Good et al. 2010
Windy Flats, WA	Johnson et al. 2007	Biglow Canyon, OR	WEST 2005c
Combine Hills, OR	Young et al. 2003c	Wild Horse, WA	Erickson et al. 2003d
Desert Claim, WA	Young et al. 2003b	North Sky River, CA	Erickson et al. 2011
Hopkins Ridge, WA	Young et al. 2003a	AOCM (CPC Proper), CA	Chatfield et al. 2010
Reardon, WA	WEST 2005a	Biglow Reference, OR	WEST 2005c
Stateline Reference, OR	URS et al. 2001	Simpson Ridge, WY	Johnson et al. 2000b
Buffalo Ridge, MN	Johnson et al. 2000a	Vantage, WA	Jeffrey et al. 2007
White Creek, WA	NWC and WEST 2005	Grand Ridge, IL	Derby et al. 2009
Foote Creek Rim, WY	Johnson et al. 2000b	Tehachapi Pass, CA	Anderson et al. 2000, Erickson et al. 2002b
Roosevelt, WA	NWC and WEST 2004	Sunshine, AZ	WEST et al. 2006
Leaning Juniper, OR	Kronner et al. 2005	Dry Lake, AZ	Young et al. 2007b
Dunlap, WY	Johnson et al. 2009a	Alta East (2011), CA	Chatfield et al. 2011
Klondike, OR	Johnson et al. 2002	Alta East (2010), CA	Chatfield et al. 2011
Stateline, WA/OR	Erickson et al. 2003a	San Gorgonio, CA	Anderson et al. 2000, Erickson et al. 2002b
Antelope Ridge, OR	WEST 2009	AOCM (CPC East), CA	Chatfield et al. 2010
Condon, OR	Erickson et al. 2002b		

Table 10. Diurnal raptor fatality rates at new-generation wind energy facilities in Minnesota.

Project Name	Raptor Fatality/MW/Year	Fatality Reference
Buffalo Ridge, Phase 1 (1999)	0.47	Johnson et al. 2000
Moraine II (2009)	0.37	Derby et al. 2010
Prairie Rose (2014)	0.08	Chodachek et al. 2015
Buffalo Ridge, Phase 1 (1996)	0	Johnson et al. 2000a
Buffalo Ridge, Phase 1 (1997)	0	Johnson et al. 2000a
Buffalo Ridge, Phase 1 (1998)	0	Johnson et al. 2000a
Buffalo Ridge, Phase 2 (1998)	0	Johnson et al. 2000a
Buffalo Ridge, Phase 2 (1999)	0	Johnson et al. 2000a
Buffalo Ridge, Phase 3 (1999)	0	Johnson et al. 2000a
Elm Creek (2009-2010)	0	Derby et al. 2010d
Elm Creek II (2011-2012)	0	Derby et al. 2012b
Big Blue (2013)	0	Fagen Engineering 2014
Big Blue (2014)	0	Fagen Engineering 2015

7.1.1.2 Passerines

Passerines are the most common bird types found at wind energy facilities in the US (Erickson et al. 2014), primarily due to their large overall abundance. While nocturnally migrating small birds represent most wind farm bird mortalities in the US, wind energy facilities are considered unlikely to adversely impact small bird populations (Loss et al. 2013b, Erickson et al. 2014). Mean passerine use at the Project was highest during migration, although seasonal use varied between study years (Appendix A, Appendix B). The results of this study show that risk of collisions with wind turbines for passerines would most likely be greatest during migration.

7.1.2 Bats

Bat fatality rates in the US range from 0.10 (Tierney 2007) to 39.70 bats/MW/year (Fiedler et al. 2007). In 2012, an estimated 600,000 bats died as a result of interactions with wind turbines in the US (Hayes 2013). Bat mortality at wind farms is largely due to collisions with moving turbine blades (Grodsky et al. 2011, Rollins et al. 2012), but the underlying reasons for why bats come near turbines are still largely unknown (Cryan and Barclay 2009). The few studies that have estimated pre-construction activity and post-construction mortality suggest a general association between activity and fatality rates, with higher or lower activity rates coinciding with higher or lower mortality rates in several cases. However, this general association is more consistent for sites with very low activity; the relationship is not as consistent for sites with moderate or higher activity (Hein et al. 2013). Bat fatality rates recorded at wind energy facilities in the Midwest are <10 fatalities per MW per year (Figure 15), and the highest number of bat fatalities in the US have occurred in August and September (Johnson 2005, Arnett et al. 2008, Derby et al. 2013c).

Bat activity rates in the Project area were low-moderate based on two years of acoustic surveys. Most bat activity was by low frequency (LF) bats (big brown, silver-haired, or hoary bats). LF species may be more susceptible to collision because they tend to fly at higher altitudes (Arnett et al. 2008). Based on the results of general acoustic bat surveys and targeted NLEB presence/probable absence surveys, bat fatality rates at the Project are expected to be low-moderate and most fatalities are expected to be migratory tree-roosting bats. Of the *Myotis* species, little brown bats may be at higher risk based on results from the NLEB presence/probable absence surveys.

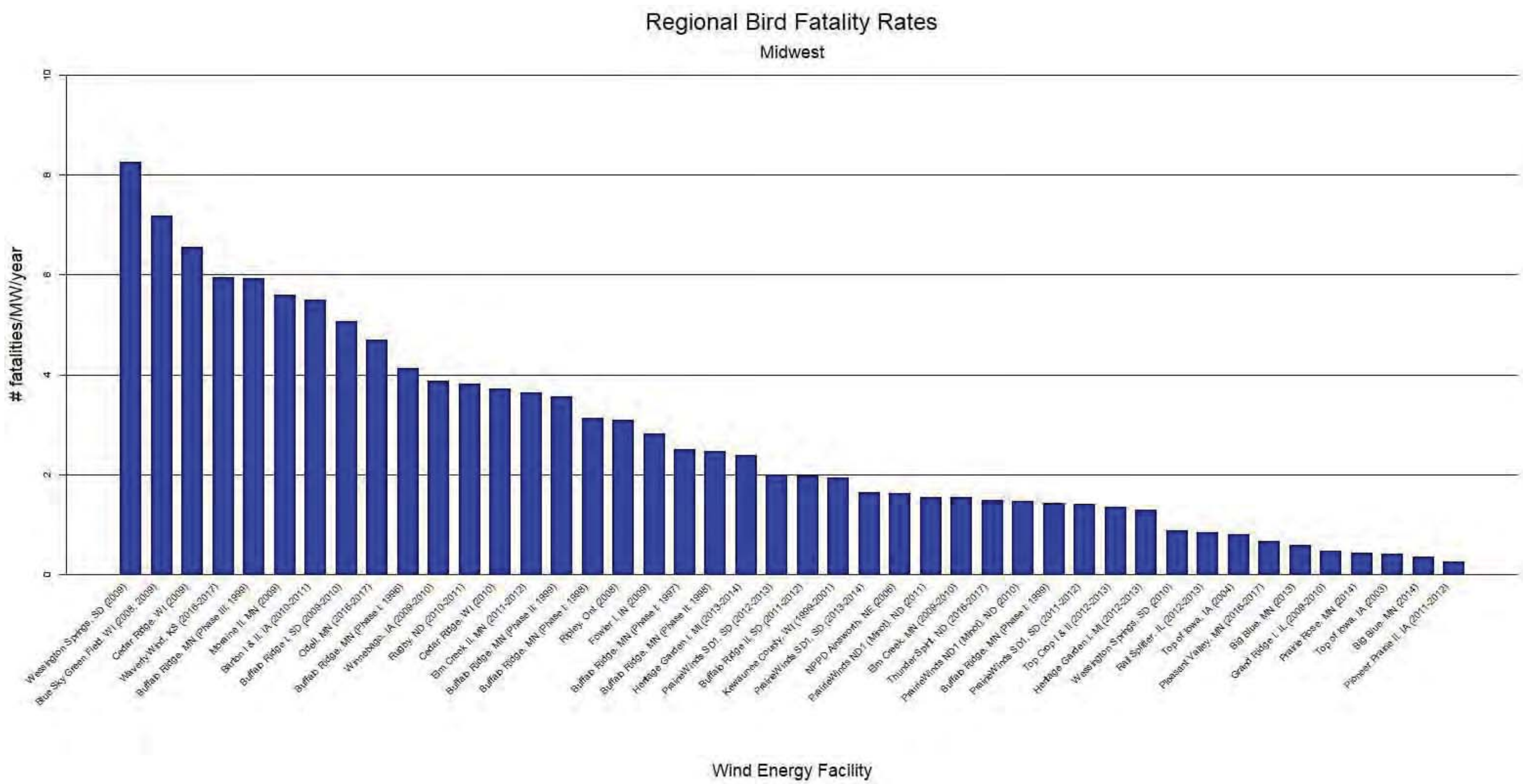

Figure 18. Fatality rates for bats (number of bats per megawatt per year) from publicly available studies at wind energy facilities in the Midwest of North America.

Figure 18 (*continued*). Fatality rates for bats (number of bats per megawatt [MW] per year) from publicly available studies at wind energy facilities in the Midwest and Southern Plains regions of North America.

Data from the following sources:

Wind Energy Facility	Fatality Reference	Wind Energy Facility	Fatality Reference
Cedar Ridge, WI (2009)	BHE Environmental 2010	Buffalo Ridge, MN (Phase III; 1999)	Johnson et al. 2000a
Blue Sky Green Field, WI (2008; 2009)	Gruver et al. 2009	Buffalo Ridge, MN (Phase II; 1999)	Johnson et al. 2000a
Cedar Ridge, WI (2010)	BHE Environmental 2011	Moraine II, MN (2009)	Derby et al. 2010e
Fowler I, II, III, IN (2011)	Good et al. 2012	Buffalo Ridge, MN (Phase II; 1998)	Johnson et al. 2000a
Fowler I, II, III, IN (2010)	Good et al. 2011	PrairieWinds ND1 (Minot), ND (2010)	Derby et al. 2011c
Forward Energy Center, WI (2008-2010)	Grodsky and Drake 2011	Grand Ridge I, IL (2009-2010)	Derby et al. 2010h
Top Crop I & II (2012-2013)	Good et al 2013b	Big Blue, MN (2013)	Fagen Engineering 2014
Rail Splitter, IL (2012-2013)	Good et al 2013a	Barton I & II, IA (2010-2011)	Derby et al. 2011a
Harrow, Ont (2010)	Natural Resources Solutions Inc. (NRSI) 2011	Fowler III, IN (2009)	Johnson et al. 2010b
Top of Iowa, IA (2004)	Jain 2005	Buffalo Ridge, MN (Phase III; 2002/Lake Benton II)	Johnson et al. 2004
Fowler I, IN (2009)	Johnson et al. 2010a	Buffalo Ridge, MN (Phase II; 2002/Lake Benton I)	Johnson et al. 2004
Crystal Lake II, IA (2009)	Derby et al. 2010b	Rugby, ND (2010-2011)	Derby et al. 2011b
Top of Iowa, IA (2003)	Jain 2005	Elm Creek, MN (2009-2010)	Derby et al. 2010d
Kewaunee County, WI (1999-2001)	Howe et al. 2002	Wessington Springs, SD (2009)	Derby et al. 2010g
Heritage Garden I, MI (2012-2013)	Kerlinger et al. 2014	Big Blue, MN (2014)	Fagen Engineering 2015
Ripley, Ont (2008)	Jacques Whitford 2009	PrairieWinds ND1 (Minot), ND (2011)	Derby et al. 2012c
Winnebago, IA (2009-2010)	Derby et al. 2010f	PrairieWinds SD1, SD (2011-2012)	Derby et al. 2012d
Pioneer Prairie II, IA (2011-2012)	Chodachek et al. 2012	NPPD Ainsworth, NE (2006)	Derby et al. 2007
Buffalo Ridge, MN (Phase II; 2001/Lake Benton I)	Johnson et al. 2004	PrairieWinds SD1, SD (2012-2013)	Derby et al. 2013a
Pioneer Prairie II, IA (2013)	Chodachek et al 2014	Buffalo Ridge, MN (Phase I; 1999)	Johnson et al. 2000a
Buffalo Ridge, MN (Phase III; 2001/Lake Benton II)	Johnson et al. 2004	PrairieWinds SD1, SD (2013-2014)	Derby et al. 2014
Crescent Ridge, IL (2005-2006)	Kerlinger et al. 2007	Wessington Springs, SD (2010)	Derby et al. 2011d
Barton Chapel, TX (2009-2010)	WEST 2011	Buffalo Ridge I, SD (2009-2010)	Derby et al. 2010b
Fowler I, II, III, IN (2012)	Good et al. 2013c	Buffalo Gap II, TX (2007-2008)	Tierney 2009
Big Smile, OK (2012-2013)	Derby et al. 2013b	Red Hills, OK (2012-2013)	Derby et al. 2013c
Buffalo Ridge II, SD (2011-2012)	Derby et al. 2012a	Buffalo Gap I, TX (2006)	Tierney 2007
Elm Creek II, MN (2011-2012)	Derby et al. 2012b		

7.2 Indirect Impacts

7.2.1 Birds

Wind energy developments can result in habitat loss or displacement of wildlife from otherwise suitable habitats (USFWS 2012, NRC 2007). Birds displaced from wind energy facilities might move to lower quality habitat with fewer disturbances, with an overall effect of reducing breeding success. Such indirect impacts typically occur near turbines or along access roads, although available data indicate that avoidance of wind turbines by birds generally extends 75 to 800 m (245 to 2,625 ft) from a turbine, depending on the environment and the bird species affected (Strickland 2004). The magnitude of such impacts at the Project is expected to be minimal, as the Project will result in a relatively small amount of habitat loss and disruption relative to the surrounding agricultural landscape.

Raptors nesting close to turbines may be disturbed during construction or operation of the wind energy facility. Most studies of raptor displacement at wind energy facilities have found negligible effects (Howell and Noone 1992; Johnson et al. 2000a, 2003; Madders and Whitfield 2006). Given the low density of raptor nests documented in or near the Project area during two years of nest surveys, limited displacement of nesting raptors is anticipated at the Project.

Wind energy facility construction can cause small-scale local displacement of grassland passerines. Construction also reduces habitat effectiveness because of the presence of access roads and large gravel pads surrounding turbines (Leddy 1996; Johnson et al. 2000a). Leddy et al. (1999) surveyed bird densities in Conservation Reserve Program (CRP) grasslands at the Buffalo Ridge wind energy facility in Minnesota, and found mean densities of 10 grassland bird species were four times higher at areas located 180 m (591 ft) from turbines than they were at grasslands nearer turbines. Similarly, Shaffer and Buhl (2015) demonstrated reduced breeding density for seven of nine breeding grassland birds and the attraction to turbines of one species (killdeer [*Charadrius vociferous*]) likely attributed to increased nesting habitat from road and pad construction. Johnson et al. (2000a) found reduced use of habitat by seven of 22 grassland-breeding birds following construction of the Buffalo Ridge wind energy facility. Results from the Stateline wind energy facility in Oregon and Washington (Erickson et al. 2004) and the Combine Hills wind energy facility in Oregon (Young et al. 2005) suggest a relatively small impact of wind energy facilities on grassland-nesting passerines. Transect surveys conducted prior to and after construction of the wind energy facilities found that grassland passerine use was significantly reduced within approximately 50 m (164 ft) of turbine strings, but areas further away from turbine strings did not have reduced bird use. Because the majority (87.1%) of the Project area consists of cultivated croplands, which have limited value to nesting passerines and other bird species, displacement impacts resulting from Project development are anticipated to be minimal. Another study in Minnesota grasslands indicated no conclusive evidence of habitat avoidance based on distance to operating wind turbines for three common grassland breeding birds (Hale et al. 2014); however, the authors acknowledge that effects in their study may have been difficult to isolate due to other factors that covary with turbine distance (e.g., presence of fence lines).

7.2.2 Bats

Due to the lack of any known bat maternity roosts or hibernacula, displacement impacts to bats are not expected at the Project.

7.3 Potential Risk to Sensitive Species

This section discusses potential risks to species that may be sensitive to wind energy development in the Project area. These include bald and golden eagles, which are federally protected under the BGEPA; northern long-eared bat, which is federally listed as threatened, and Henslow's sparrow, which is state-listed endangered.

7.3.1 Bald Eagle

Bald eagle abundance in southwestern Minnesota and northeastern Iowa is generally higher during migration or winter and lower during the nesting season (eBird 2019). Winter habitat is typically associated with open water, but may include any habitat with an available food source (Buehler 2000). Habitat during migration is similar (Buehler 2000), although food availability may differ between seasons. Nesting habitat typically includes mature trees near large water bodies (Buehler 2000), although nests can also occur in atypical habitats (Guinn 2004).

The Project area is largely dominated by cropland, and lacks features that would attract high bald eagle use. Bald eagle use was generally low during both years of avian use surveys. No bald eagle concentration areas were identified in or near the Project area. Bald eagle use was higher during migration. Suitable nesting habitat is available, but limited by the lack of mature trees. Eight occupied and active bald eagle nests were recorded during both the 2017 and 2018 aerial nest surveys within 16 km (10 mi) of the Project, but none were within 3.2 km (2.0 mi). Therefore, the Project poses low risk to bald eagles.

7.3.2 Golden Eagle

Golden eagles are uncommon in southwestern Minnesota and northeastern Iowa (eBird 2019). The small number of golden eagle observations recorded during baseline studies within and near the Project area suggests that golden eagle use in the area is low, although an occasional individual may pass through during migration. One golden eagle was observed in spring during the two years of eagle use surveys. Potential roost sites are limited within the Project area and surrounding area due to a lack of rock outcrops and cliffs. The generally flat topography of the Project area is not expected to create conditions suitable for strong updrafts of wind and would not be expected to greatly influence the potential collision risk to golden eagles. Impacts to golden eagles are not expected.

7.3.3 Northern Long-eared Bats

The federally threatened northern long-eared bat is known to potentially occur in the Project area (Appendix G). The Project area is not located near any large, known bat colonies, water sources, caves, rocky outcrops, or other features that are likely to attract large numbers of northern long-eared bats. In addition, the Project area does not contain topographic features that may funnel migrating bats, and the Project area has few trees for roosting areas. No northern long-eared bats were detected during acoustic surveys targeting this species in the Project area. Impacts to northern long-eared bats are not expected.

7.3.4 Henslow's Sparrow

The Project area lacks grassland habitat suitable for Henslow's sparrows. During the two years of avian use studies at the Project, one Henslow's sparrow was observed during the fall of 2017 (Appendix A). Henslow's sparrows are unlikely to use the Project area during the breeding season, but have a small potential to use any large flat fields containing dead standing vegetation during migration. Impacts to Henslow's sparrow are not expected.

8 AVOIDANCE AND MINIMIZATION MEASURES

Information gathered during Tier 1-3 studies was used to inform Project design and turbine siting to reduce potential impacts to birds and bats. The following conservation measures will be implemented during the design, construction, and operational phases of the Project. These measures demonstrate Three Waters' effort to minimize impacts to birds and bats at the Project.

8.1 Conservation Measures Implemented During Site Selection and Project Design

Based on the initial Tier 1-3 studies, Three Waters determined the Project area to be the preferred location for a wind energy project based upon the following reasons related to potential avian and bat impacts:

- The Project area does not contain known federally threatened or endangered species or designated critical habitat.
- Eagle and raptor use of the Project area is considered low for the region.
- The Project area contains few wetlands and/or streams.
- The Project area is dominated by cultivated cropland (89.9% of total area).

Three Waters will make efforts during initial site selection and during project design to locate and select wind turbines, met towers, and other appurtenances such that bird and bat collisions are minimized. Project design and siting measures to avoid or minimize risk to avian and bat species will include the following:

- Use the existing road network to reduce the need for road construction.
- Coordinate with the Federal Aviation Administration to minimize the number of wind turbines and met towers that require lighting.
- Keep lighting at substations and other facilities at a minimum required for safety and security needs (i.e., directional, hooded and/or shielded, low-intensity, low-sodium lights equipped with motion sensors). Extinguish all internal turbine nacelle and tower lighting when unoccupied.
- To the extent commercially reasonable, maximize power generation per turbine in order to reduce the number of turbines needed to achieve maximum energy production.

8.2 Conservation Measures to be Implemented during Construction

Construction of the Project is expected to begin in 2021 and occur over a period of approximately 12 months. Construction activities will involve the heaviest use of the site during the life of the Project. The following conservation measures (CMs) will be implemented to avoid or minimize risk to avian and bat species during construction:

- Vehicle speeds will be limited to 25 miles-per-hour (mph) to avoid and minimize wildlife collisions. Construction vehicles will be restricted to pre-designated access routes. Following Project construction, roads not needed for site operations will be restored to native vegetation.
- To the extent feasible, the area required for Project construction and operation will be minimized. Three Waters will develop a restoration plan for restoring all areas of temporary disturbance to their previous condition, including the use of native species when seeding or planting during restoration. The restoration plan will ensure:
  - All areas disturbed temporarily by Project construction will be restored including temporary disturbance areas around structure construction sites, laydown/staging areas, and temporary access roads.
  - Topsoil salvage will be included in all grading activities.
  - The inclusion of performance criteria, habitat replacement specifications, and tentative time frames for restoration of the site in addition to provisions for a monitoring program to assess the success of the restoration efforts.
- Appropriate natural fiber erosion control methods will be used during construction to eliminate or minimize runoff and avoid impacts to hydrology.
- Three Waters will develop and implement a noxious weed control plan in accordance with the land lease agreements.
- Gravel will be placed at least 1.5 m (5 ft) around each turbine foundation to discourage small mammals and reptiles from burrowing under or near turbine bases.
- Sensitive resources (e.g., nests) identified during pre-construction activities will be flagged and all site personnel notified of their presence and necessary setbacks.
- No unleashed dogs will be allowed on the Project site during construction.
- All trash will be covered in containers and work sites will be cleared daily of any garbage and debris related to food.
- All permanent met towers will be un-guyed.
- All power lines will be constructed in accordance with the most current Avian Power Lines Interaction Committee (APLIC) Guidelines (APLIC 2012) to protect birds from electrocution and collision.

8.3 Conservation Measures to be Implemented during Operations

- Low speed limits (e.g., less than 25 mph) will be enforced on all roads within the facility.
- Other than maintenance vehicles which will park at the entrance of turbines for maintenance purposes, parts and equipment which may be used as cover for prey will not be stored at the base of wind turbines while a turbine is operational and spinning.
- Fire hazards from vehicles and human activities will be reduced (e.g., use of spark arrestors on power equipment, avoiding driving vehicles off roads, allowing smoking in designated areas only).
- Three Waters will develop and implement a noxious weed control plan in accordance with the land lease agreements.
- Pest and weed control measures will be implemented as specified by county, state, and federal requirements.
- A one-year avian and bat fatality monitoring program will be implemented at the start of operation.
- A carcass removal program will be implemented to minimize potential attractants for carrion-feeding raptors.
- All of Three Waters' employees and contractors working on site will receive worker awareness training for identifying and responding to encounters with sensitive biological resources, including bird and bat species. The training:
    - Will be conducted by Three Waters or their designee.
    - Will include instructions for all employees, contractors, and site visitors to avoid harassing or disturbing wildlife.
    - Will include instruction on identification and values of plant and wildlife species and significant natural plant community habitats, fire protection measures and measures to minimize the spread of weeds during construction as well as hazardous material spill and containment measures.
    - Will include a flier to be distributed to all workers on the Project detailing information on potential state and federal special-status animal and plant species that might be discovered on the Project site.
    - Will include an overview of the distribution, general behavior, and ecology of golden and bald eagles. Employees will be informed that they are not authorized to approach, handle, or otherwise move any eagles that might be encountered during construction, whether alive, injured, or deceased. Operations personnel will be instructed to report any finding of an injured or deceased eagle to USFWS within 24 hours of positive identification by a qualified biologist.

9 POST-CONSTRUCTION MONITORING: TIER 4

9.1 Tier 4a – Bird and Bat Fatality Monitoring

To estimate bird and bat mortality rates, Three Waters will conduct post-construction fatality monitoring at the Project. Post-construction fatality monitoring will consist of one year of third-party monitoring followed by continued operational staff monitoring for the life of the Project.

9.1.1 Third-Party Monitoring

During the first year of commercial operations, third-party fatality monitoring will be conducted following guidelines provided in the WEG and MNDNR's *Avian and Bat Survey Protocols for Large Wind Energy Conversion Systems in Minnesota* (Mixon et al 2014). Based on the results of Tier 3 studies outlined in this BBCS, Three Waters is developing a monitoring protocol for low-risk sites. This protocol will include carcass searches between March 15 and November 15. Search methods will be determined through coordination with the MNDNR. Proposed methods consist of weekly searches at 45 turbines, including five 120 m x 120 m plot searches and 40 road and pad searches.

Fatality rate estimates will factor in searcher efficiency and carcass persistence following recommendations of the MNDNR (Mixon et al. 2014). Searcher efficiency will be determined by placing 100 total carcasses, including 15 small bird carcasses, 15 large bird carcasses, and 20 bat/surrogate carcasses on each survey plot type (i.e., road/pad and full plot). Carcass persistence rates will be determined by placing 135 total carcasses, with 15 small bird carcasses, 15 large bird carcasses, and 15 bat/surrogate carcasses per season (i.e., spring, summer, and fall). Carcass persistence trial carcasses will be roughly divided between full plot and road/pad survey plots in each season to allow for differentiation of rates between plot types. Fatality rates will be estimated using two estimators approved by the USFWS and MNDNR. Proposed estimators include the Shoenfeld and Huso estimators.

A final report will be shared with the MNDNR following the first year of third-party fatality monitoring. This report will follow the Fatality Report Guidelines provided by the MNDNR (Mixon et al. 2014). The report will describe the results of mortality surveys, searcher efficiency trials, and carcass removal trials. All equations and methods used to estimate fatality rates will be provided. Results will be discussed with the MNDNR to determine if an additional year of monitoring is needed. Any federally protected species found during third-party monitoring will be reported to the USFWS within 24 hours of identification. Any incident involving a state-listed threatened or endangered species will be reported to the MNDNR within 24 hours of identification.

9.1.2 Operational Staff Monitoring

Operational staff will be trained to monitor for dead or injured golden eagles, bald eagles, and other sensitive wildlife species during their work activities. A data sheet that describes how Project personnel can recognize an injured or dead eagle or sensitive species will be posted in the maintenance facility. The data sheet will include instructions on how to proceed if an injured or dead bald eagle, golden eagle, or other protected species is discovered onsite. Any federally protected species found during third-party monitoring will be reported to the USFWS within 24 hours of identification. Any incident involving a state-listed threatened or endangered species will be reported to the MNDNR within 24 hours of identification.

9.2 Tier 4b – Assessing Impacts to Habitat

No Tier 4b studies to assess impacts to habitat or species of special concern are deemed necessary at this time, based on Tier 3 findings.

10 RESEARCH: TIER 5

In addition to Tiers 1-4 described above, the WEG describe *Tier 5 Other Post-Construction Studies*. Typically, Tier 5 studies are research related and, as written in the WEG, "will not be necessary for most wind energy projects." Based on results of Tier 1-3 studies and the expected results of Tier 4 studies, no Tier 5 studies are anticipated.

11 ADAPTIVE MANAGEMENT

The WEG define adaptive management as "an iterative decision process that promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood" (USFWS 2012). The WEG also notes that adaptive management is unlikely to be needed at wind energy facilities that are sited in accordance with the WEG's tiered approach. Nevertheless, Three Waters will incorporate an adaptive approach for the conservation of wildlife potentially impacted by the Project

Based on Project siting and the results of Tier 1-3 studies, no significant adverse impacts are anticipated from the Project and mortality is expected to fall within the overall range of other projects in the Midwest. Tier 4 post-construction monitoring will be conducted to estimate the actual level of bird and bat mortality at the Project. If impacts are minor, no further action will be required. Should Tier 4 studies indicate higher impacts than anticipated, adaptive management measures will be considered to further avoid, minimize, or compensate for impacts to wildlife. Thresholds for considering an adaptive response may include:

- Mortality of an eagle or a species listed as state or federal endangered/threatened; or
- Significant levels of mortality of unlisted species of birds or bats. Significance will be determined by qualified biologists and will be based on the latest information available, including the most recent data on species' population sizes and trends. For example, even relatively high levels of mortality of the most common species may not be significant. Conversely, lower levels of mortalities of less common species may be of more concern, particularly if these species appear to be at risk (e.g., USFWS Birds of Conservation Concern).

If impacts are higher than anticipated, potential causes will be evaluated to help determine appropriate mitigation actions. If causal factors are not identified, further monitoring efforts may