User Guide:
Wisconsin Land Economic Inventory (WLEI) Digitized Maps

History and Background Information

The WLEI was a comprehensive and extremely detailed mapping of Wisconsin's counties. The genesis of the program was in the Progressive era. By the 1920s court and law rulings had clarified that states had authority for land use planning that included private lands. Following the cutover era in Northern Wisconsin, with devastated forests, burned land, and abandoned farms, the state of Wisconsin saw the need for comprehensive inventory of the land to guide planning.

Field mapping started in 1928, and it was completed under WPA funding in the late 1930s. Each township was inventoried by crews traversing each section of land along the "40" lines, or every one-quarter mile. Essentially everything about the land and what was on it was mapped and described. Eventually this resulted in over 100 classes of information, from polygons of forest type and quality, to detailed classes of agricultural use, and all infrastructure features that could be identified. The survey was executed by field workers who were by and large trained foresters, with a standard accuracy of 2 chains for open country, and 4 chains (1 chain = 66') for wild or densely wooded country. Field workers' hand drawn maps were later adjusted with aerial photography to produce a published maps for nearly every township in Wisconsin.

The published maps – often referred to as the Bordner maps named for the director of the program – have been optically scanned and are available online through the UW Libraries Digital Collections site (https://uwdc.library.wisc.edu/collections/EcoNatRes/WILandInv/). Milwaukee and Menominee Counties were not mapped. Lincoln, Manitowoc, and Sheboygan County township maps were never published. For those counties with unpublished maps, the original sketch maps were located in the Historical Archives at the Wisconsin Historical Society, and scanned.

While the original published maps offer an insight to landscape features, they do not allow for complex analysis using modern technologies and techniques. Over seventy years after the last map was published, the Forest Ecosystem and Landscape Ecology Lab (FLEL) of the University of Wisconsin-Madison, Department of Forest and Wildlife Ecology has collaborated with the Wisconsin State Cartographer's Office (SCO) to digitize the maps into a GIS dataset and make the data available to the public. This digitized dataset can help researchers and educators further understand the landscape of Wisconsin during the time of peak deforestation and land abandonment. Furthermore, this digitized dataset offers a tool for future landscape management including but not limited to; shoreline changes, erosion, reforestation, and wetland restoration.

Digitization Processes and Methodology

Step 1: Georeference Original Maps

First part of the GIS digitization process of the Bordner survey maps was to georeference the original published township maps. Using section line intersections as a reference, these scanned maps were then georeferenced to the Department of Natural Resource's 'Landnet' GIS database layer containing the section lines, using section line intersections as tie points. In cases where there were missing section lines on the original maps, aerial photography was used to help with geo-referencing. The maps were referenced using

the NAD 1983 HARN Transverse Mercator coordinate system, with the transformation "adjust", and an output raster having a cell size of 1m.

Step 2: Digitize

Next the section lines for a given township were overlaid on top of the geo-referenced image using a hollow display.

> Polygons:
> Polygon features include land cover land use features, such as forest, agriculture, lakes etc. Polygon features were cut using the "Cut Polygon" editing tool by tracing the land cover land use boundary lines on the geo-referenced maps. Wacom digitizing tablets were used to increase digitization precision and speed.
>
> Lines:
> Linear features include roads, telephone lines, power lines, streams etc. Digitizers traced these features, and in cases where two or more features followed the same path, one line was drawn then copied and pasted to insure accuracy. Linear features that cross township borders were sometimes displaced slightly when their path didn't match exactly between two georeferenced township maps.
>
> Points:
> Point features include houses, churches, cheese factories, mills, taverns etc. Digitizers place the appropriate point in the center of these features. In some cases the map indicates number of buildings in a group and/or the distance a building is located from a road, this information was also captured by the digitizers.

Step 3: Assign Attributes

Point and line features were attributed during the digitization process.

Once all of the polygon features for a township were cut, they were each assigned an attributes reflecting the information present on the original map. Land Cover, Diameter Classes, and Density of Stand were all captured during the attribution process. Labels for water bodies and urban areas were documented in the "*Notes*" field when present. In cases where survey lines were unclear, or polygons were left blank, judgment calls were made using the help of aerial photography when necessary. In these instances the type of judgement call that was made was recorded in the database, often with a note explaining the judgement call in the "*Notes*" field.

Step 4: Review

Finally, when all of the survey maps for a county were digitized and attributed, they were then reviewed for quality control. This review process consisted of checking for null values, sliver and overlap of polygons (topology), diameter and percentage outliers, and an overview of the documented notes/judgment calls. After reviewing the digitization work, all of the individually digitized townships were merged for their given county and stored in a geodatabase for future processing.

<u>Additional Information Regarding the Bordner Dataset</u>

- Some land cover polygons have up to four forest cover species. In some cases the original survey maps included a percentage for polygons with more than one cover type, however in many cases they did not.
- The Bordner Survey was a project that took 20 years to complete. Dates for each county can be found online at: https://www.library.wisc.edu/steenbock/wisconsin-land-economic-inventory-the-bordner-survey-land-cover-maps/. In some cases bordering counties could have over a decade between the production of survey maps.
- Section lines were used for the digitization process. Sometimes these lines transverse a single polygon feature, dividing it into a few smaller polygons. This can cause inaccuracies when trying to count a number of stands, or calculate average size of a stand, etc.
- Some maps have land cover codes that remain unknown due to fact the were absent from the legend.
- When a polygon was missing a land cover attribute in the original maps, historic aerial photos were used to identify whether the land cover should be attributed as either "unknown forest" or "unknown grassland".

Field Descriptions

Polygons:

Field	Description
Cov1	Dominant Cover Type
MinDiam1	Minimum Diameter Size at Breast Height for Cov1
MaxDiam1	Maximum Diameter Size at Breast Height for Cov1
Den1	Density for Cov1
PctCov1	Percent of Stand that Cov1 Occupies (not all townships include this)
Cov2	Second Most Prevalent Cover Type
MinDiam2	Minimum Diameter Size at Breast Height for Cov2
MaxDiam2	Maximum Diameter Size at Breast Height for Cov2
Den2	Density for Cov2
PctCov2	Percent of Stand that Cov2 Occupies (not all townships include this)
Cov3	Third Most Prevalent Cover Type
MinDiam3	Minimum Diameter Size at Breast Height for Cov3
MaxDiam3	Maximum Diameter Size at Breast Height for Cov3
Den3	Density for Cov3
PctCov3	Percent of Stand that Cov3 Occupies (not all townships include this)
Cov4	Fourth Most Prevalent Cover Type
MinDiam4	Minimum Diameter Size at Breast Height for Cov4
MaxDiam4	Maximum Diameter Size at Breast Height for Cov4
Den4	Density for Cov4
PctCov4	Percent of Stand that Cov4 Occupies (not all townships include this)
Judgement Call	Confusing Line Work, Missing Attribute, Missing Line, Poor Scan/Faint Lines
Notes	Labels, Unique Features, Details Regarding Judgement Calls

- Crown Cover Dominance:
    - *Cov2, Min2, Max2* etc. indicates a secondary cover within a stand, there are up to 4 different cover types within a single polygon (*Cov1*..., *Cov2*..., *Cov3*..., *Cov4*...). Dominance is determined by the relative amount of space occupied by each type in the combination. Neither the size nor the

number of trees alone will indicate the correct result. It must be remembered that it requires many small trees, size 0-3, to occupy as much space from the site of a single 30 inch tree.

- Diameter Classes:
    - The approximate age and size of the forest growth is indicated on the map, in three-inch diameter classes, by the figures in type symbol.
        - 0-3 indicates that the -majority of the trees are less than three inches in diameter.
        - 3-6 indicates that the -majority of the trees are between three and six inches in diameter.
        - 6-9 indicates that the -majority of the trees are between six and nine inches in diameter.

- Density indicates the relative number of trees per acre and the completeness with which they utilize the available land and light. Young forest growth in any degree of stocking will have more trees per acre than a mature stand of the same degree of stocking.
    - 1-Good Stand = Trees are so numerous that there is little to no waste of land or light, the individual trees develop small crowns and tall, clean straight bowls. Such stands need no artificial seeding or planting to obtain full use of land and light by forest growth.
    - 2-Medium Stand = Trees are less numerous and openly spaced so that there is material waste of land and light. Some of the individual trees develop rather large, irregular crowns and knotty crooked bowls. Such stands may need some natural artificial seeding or planting to obtain full use of the land and light by forest growth.
    - 3-Poor Stand = Trees are so few and scattered that there is a very considerable waste of land and light. Many individual trees develop spreading, limby crowns and short knotty trunks. Such stands need much artificial seeding or planting to obtain full use of the land and light by forest growth.
    - 4-Scattered Stand
- Coded Symbol First letter (eg. A1, B2, C4) generally does not represent a specific land cover type.
- Coded Symbol Additional Letters (eg. C4b, D1u, D1uu)
    - b = Inferior (represented on the original map as one line ABOVE the coded symbol)
    - u = Unknown (represented on the original map as one or more lines BELOW the coded symbol)
    - A, R, RS, RX, RY, X, Y, Z = All appear to be variations of agricultural cover types (eg. CPP; CPPA, CPPR, CPPRX etc.)
    - Note that b does not always indicate inferior and little to no documentation can be found to the meanings of u, uu, uuu, and uuuu. These symbols appear as a line *above* the Cover Code for b, and one to four lines *below* the Cover Code for u on the original published maps.

Lines:

Field	Description
Line_Type	Indicates the type of line represented
Highway_Ty	Indicates the type of highway; county, state, or federal
Highway_Co	Indicates the highway code. County Highways represented in letters, State and Federal Highways represented as a number
Notes	Labels, Judgement Calls, etc.

- Cliff heights are indicated in the *Notes* field (eg. '60).
- Banks are indicated with *Line_Type* = CL AND *Note* = Bank (ex. 20-50' Bank).
- When more than one *Highway_Ty* covers a particular stretch of road, the secondary *Highway_Co* is indicated in the *Notes* field.
- Other labels including Railroads and Streams are indicated in the *Notes* field.

Points:

Field	Description
Point_Type	Indicates the type of point represented
Num_of_Hou	Indicates the number of houses in a group
Dis_to_Roa	Indicates the number of feet a building is located from the center of a road
Notes	Labels, Judgement Calls, etc.

Land Cover Descriptions

UPLAND FOREST ASSOCIATIONS:

Basswood, birch, maple, ash, elm -- A1 - The forest association of the better hardwood site.
Maple, birch, hemlock, balsam, fir -- B1 - The more common hardwood association in Upper Wisconsin.

1. Popple and white birch predominant -- C1
(i.e.) This association may seed in on almost any site. However, the popple appears almost pure, except on gravelly rolling sites, then white birch occasionally makes up the dominant part of the association.

2. Scrub oak predominant -- B1
 (i.e.) Scrub oak frequently is the survival of frequent fires on Norway and white pine sites, i.e. it is sprout growth. Red maple and white birch frequently appear with scrub oak on the less severely burned areas.

3. Cheery predominant -- E1
(i.e.) Pin or so-called "fire" cherry in some areas is the immediate succession generally of a very severe burn following the logging of virgin hardwood hemlock stands.

4. Hemlock predominant with hardwoods and balsam –- A2
(i.e.) Hemlock predominant appears in very old stands where the hardwood was either logged or where decay eliminated many of the very old hardwoods and the hemlock of the under story became dominant. (Few Remain)

5. White pine predominant with some Norway -- B2
 (i.e.) The association of white pine and Norway or either with for example, hardwood, and especially C1, is generally on the better white pine sites.

6. Norway pine predominant with some Jack pine – C2
(i.e.) Where Norway is predominant the site may still be capable of producing excellent white pine but frequent fires have destroyed the less resistant white pine and left the more resistant Norway pine.

7. Jack pine predominant with some Norway pine -- D2
(i.e.) Jack pine in natural forest successions falls out of the picture, following the logging of the virgin white pine and Norway pine. Followed by frequent burns, has occupied some areas almost completely due to its fire habit and early seeding potential.

LOWLAND FOREST ASSOCIATIONS:

8. Elm, Black Ash, Red Maple, White Pine --A3
(i.e.) This Land association is not very extensive and quite variable being found on stream bottom lands and also in so-called black ash swamps where little other than black ash appears in the stand.

9. Cedar predominant with some Tamarack, Balsam and Spruce --B3
(i.e.) This association may appear on almost any naturally wet land where drainage is sufficient to keep the soil from becoming strongly acid.

10. Tamaracks predominant with some Cedar, Balsam and Spruce --C3
(i.e.) The more poorly drained lowland sites have this association.

11. Spruce, Balsam Predominant -- D3
(i.e.) This is the least desirable of wetland. Spruce has changed from white to black and the leather leaf bog is the final succession on much of this site.

MARSH AND BOG VEGETATION TYPES:

12. High Shrub Type -- A4. Alder, Willow, Red Dogwood, etc.
(i.e.) Alder, willow, the red dogwood, striped maple and numerous species of the honeysuckle family, appear in this association and sometimes completely occupy the site barring the possible seeding in of forest species. However, where this is true, such disturbing bionomic factors as for example, fire and lumbering operations are primarily casual in bringing about the successions.

13. Cat Tail Marsh -- B4.
Grass Meadow -- C4.
(i.e.) Cat Tail marshes are not numerous but-sometimes appear where water levels have been suddenly changed by beaver dams and also by power dams. Sudden drainage or the lowering of the water table is followed by the grass meadow.

14. Leather Leaf Bog -- D4.
(i.e.) The leather leaf bog is always evidence of extremely toxic soil conditions and is the final succession with the Leather (heather) vegetation dominant.

OPEN WILD TYPE OF GROUND COVER:

15. Raspberries, etc. – A5.
Briars, sweet fern and grass – B5
Arbutus and winter-green, Blue berry, - Bear berry -- 05.
Recent burn -- D5.
(i.e.) These upland ground cover associations are in general an index of site. However, in some instances fire has been such a disturbing factor, that their presence may be a final survival. Again the condition of the soil has been changed by the fires, so that for example, sweet fern and even bracken thrives better than the more tolerant heather plants such as blue berry, bear berry, arbutus and winter-green.

Funding/Credits

<u>Sources</u>

Koch, John. "Touching Every Forty: John Bordner and The Wisconsin Land Economic Inventory." *Wisconsin Magazine of History*, 2006, pp. 14–25.

"Land Economic Inventory Maps (Bordner Survey)." *Wisconsin Historical Society*, 24 Aug. 2012, www.wisconsinhistory.org/Records/Article/CS3338.

"Wisconsin Land Economic Inventory Maps (The Bordner Survey)." *Steenbock Library*, 3 Nov. 2016, www.library.wisc.edu/steenbock/wisconsin-land-economic-inventory-the-bordner-survey-land-cover-maps

"Wisconsin Land Economic Inventory Mapping Instructions for Vilas County, Wisconsin." Vilas County, Wisconsin, 1930.

Point Feature	Count
Beaver Dam	9
Cannery/Canning Factory	1
Cemetery	343
Cheese Factory	303
Church	275
Country Club	1
Creamery	23
Dam	24
Erosion	101
Farm Bldg. Less than 100 ft from center of Road	210
Filling Station or Garage	214
Fire Tower	34
Fish Hatchery	4
Fur Farm	64
Golf Course	11
Gravel Pit	493
Greenhouse	1
Grist Mill	9
Hotel	27
Lime Kiln	1
Logging Camp	43
Nursery	31
Occupied House	38,086
Occupied School	830
Orchard	1,972
Post Office	2
Quarry	34
Ranger Station	2
Ruins	1
Saw Mill	36
Ski Jump	8
Spring	387
Store	192
Summer House	1,754
Tavern	431
Town Hall	58
Unknown	179
Vacant House	2,273
Vacant School	20
Total	**48,487**

Linear Feature	Count	Total Length(miles)
Abandoned Railroad	618	652
Bog Shoreline	107	51
Civil Town Boundary	324	329
Cliff	256	126
Drainage Ditch	932	742
Drivable Fire Lane	142	321
Hard Surfaced Road	745	1,430
Improved Dirt Road	6,808	5,187
Improved Gravel Road	3,115	4,975
Intermittent Stream	1,703	886
Non-Drivable Fire Lane	26	56
Power Line	3,313	4,222
Railroad	543	1,549
Shoreline	59	39
Stream	7,130	7,030
Telephone Line	3,690	5,150
Trail	1,942	1,363
Unimproved Dirt Road	4,486	2,662
Unimproved Gravel Road	1,882	2,230
Unknown	29	18
Total	**37,850**	**39,021**

Code	Code Description	Polygon Count	Acres	Code	Code Description	Polygon Count	Acres
A	Abandoned	1,057	18,067	C1b	Inferior C1	4,083	290,917
A1	Upland Hardwoods	25,419	776,637	C1uu	C1uu	9	294
A1u	A1u	2	28	C2	Norway Pine	1,471	47,304
A1uu	A1uu	4	59	C3	Tamarack	4,460	140,392
A2	Hemlock with Hardwood	3,048	169,314	C3uu	C3uu	1	66
A3	Swamp Hardwoods	19,251	627,720	C3uuu	C3uuu	2	9
A3u	A3u	1	48	C4	Grass Marsh	20,207	537,556
A3uu	A3uu	2	27	C4b	Sedge Marsh	6,132	188,866
A4	Tagalder, Willow, Dogwood, Etc.	16,955	413,815	C4u	C4u	87	4,062
A5	Raspberries, etc.	49	3,193	CA	Camp	16	258
AA	AA	1	7	CAT	Catalpa Plantation	2	7
AC	AC	19	455	CC	CC	1	52
AO	AO	2	29	CCC	CCC	6	62
AP	Abandoned Pasture	764	18,759	CL	Clay Pit	126	8,976
AR	AR	8	315	CM	Cemetery	706	3,033
ARPT	Airport	12	587	CO	County Farm	1	3
ARX	ARX	1	10	CP	CP	22	291
AX	AX	2	60	CPP	Poor Land Previously Cropped	2,252	63,327
AY	AY	2	42	CPPA	CPPA	18	745
AZ	AZ	6	152	CPPR	CPPR	4	194
B	Birch	902	18,402	CPPRX	CPPRX	4	78
B1	Hardwood with Conifers	14,005	747,841	CPPRY	CPPRY	4	133
B1b	Inferior B1	710	49,307	CPPRZ	CPPRZ	2	78
B2	White Pine	2,904	79,073	CPPX	CPPX	32	830
B2b	B2b	2	25	CPPY	CPPY	9	253
B3	White Cedar	9,367	326,776	CPPZ	CPPZ	7	157
B4	Cat Tail Marsh	1,086	37,299	CR	CR	74	2,749
B5	Briars, sweet fern and grass	1	16	CRS	CRS	1	9
BA	Ball Park	1	7	CRX	CRX	38	1,666
BB	Blueberry	30	1,298	CRY	CRY	44	2,439
BD	Beaver Dam	1	3	CRZ	CRZ	16	694
BE	Bee Farm	1	2	CS	Cultivated Stump Land	245	2,903
BF	Beaver Flowage	18	444	CT	City	1,526	240,042
BL	Blowdown	1	17	CUT	Cutover	30	5,521
BOG	Bog	3	14	CV	Urban Property	1	7
BP	Beaver Pond	25	242	Cx	Cx	723	46,243
BU	Bluff	1	5	CY	CY	251	14,165
BY	Brick Yard	3	24	CZ	CZ	42	1,953
C	Cleared Cropland	57,947	5,812,310	D	Scrub Oak	3,292	150,711
C1	Popple with White Birch	39,345	2,532,490	D1	Oak - Hickory	11,162	325,243

Code	Code Description	Polygon Count	Acres	Code	Code Description	Polygon Count	Acres
D1b	Inferior D1	8	343	MF	Mud Flats	29	822
D1u	Good Quality with White Oak	1,204	31,242	MP	Marl Pit	1	4
D1uu	Medium Gr. Mostly Red Oak	3,489	87,983	MY	Mill Yard	13	359
D1uuu	D1uuu	144	2,298	NF	National Forest	12	5,948
D2	Jack Pine	4,684	224,413	NP	NP	2	39
D3	Black Spruce	12,097	363,808	NU	Nusery	35	672
D3b	Balsam	1,486	47,814	O	Open	5,556	191,979
D3u	D3u	2	45	OA	OA	3	39
D4	Leather Leaf	4,746	86,395	OC	OC	3	38
D4b	D4b	2	19	OP	Open Pasture	5	58
D5	Recent Burn	1,046	83,962	OPP	OPP	2	21
D5b	Dead Timber	125	6,104	OR	Orchard	2,587	19,377
DA	DA	6	279	ORB	Old River Bed	21	424
DH	DH	1	8	P	Pasture	18,448	262,002
Duu	Duu	4	84	P.V.	P.V.	14	110
Duuu	Duuu	5	46	PA	PA	79	1,142
E1	Pin Cherry	1,498	76,132	PD	Public Dump	63	870
E2	E2	1	9	PG	PG	1	4
E3	E3	5	114	PK	Park	26	593
E4	Weedy Peat	366	15,931	PO	PO	1	14
EP	EP	2	15	PP	Permanent Pasture	10,969	163,319
ER	Erosion	408	1,977	PPR	PPR	5	86
F	F	32	202	PPRX	PPRX	3	74
F4	Cranberry Marsh	31	741	PPX	PPX	31	354
FF	Fur Farm	57	1,470	PPY	PPY	29	408
FG	Fair Grounds	2	53	PPZ	PPZ	17	234
FH	FH	1	12	PR	PR	9	78
FP	Forest Plantation	52	789	PRX	PRX	2	56
FX	Fox Farm	2	26	PRY	PRY	3	51
GC	Golf Course	112	6,021	PRZ	PRZ	2	20
GG	GG	33	206	PS	PS	1	4
GP	Gravel Pit	160	1,457	PX	PX	89	1,188
Gr	Gravel	7	181	PY	PY	59	895
IN	IN - Indian Mounds	1	5	PZ	PZ	82	987
IS	Island	184	575	Qz	Quarry	50	713
K	K	2	71	RC	Red Cedar	14	259
KC	Kentucky Coffee Trees	1	1	RCT	Recent Cut	3	166
LA	Lake Dried Up	1	3	RE	Reserve	2	71
LO	Locust	2	15	Rec	Recreation Area	57	1,999
MA	Maple	17	333	RM	RM	1	5

Code	Code Description	Polygon Count	Acres
RO	Rock Outcrop	77	1,199
S	Stump	1,250	32,241
Sand	Sand	25	671
SB	Sand Bar	10	55
SC	SC	39	679
Sch.Gs	Sch.Gs	1	4
SD	SD	34	1,577
SF	State Farm	1	78
SFH	State Fish Hatchery	1	77
SFN	State Forest Nursery	1	93
SL	Slash	37	1,881
SLP	Slag Pile	1	14
SN	SN	57	4,741
Snags	Snags	2	26
SP	Stump Pasture	18,749	320,193
SPC	SPC	1	47
SPRZ	SPRZ	1	11
SPX	SPX	25	483
SPY	SPY	29	570
SPZ	SPZ	9	100
SR	SR	1	61
SRG	Spring	4	19
St	Shoal Bottom With Debris	17	745
STKYD	Stock Yard	2	3
U	U	86	3,153
UF	UF	4,651	42,677
UG	UG	2,328	20,875
UR	UR	100	311
Urban	Urban	312	9,670
WD	Windfall	2	1
WE	WE	2	36
WO	Open Water	11,374	978,188
WR	River	4,977	81,174
Z	Z	1	7
Total		**364,629**	**16,915,530**