14090
Great Lakes Alvar

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Vegetation Type
Steppe/Savanna

Map Zones
50, 64

Geographic Range
Great Lakes alvars occur in Michigan (Lee et al. 1998), New York (Reschke 1990), Ohio, Wisconsin (Judziewicz 2001) and the Canadian province of Ontario (Brownell and Riley 2000). In Michigan, alvar occurs in the Upper Peninsula near the shorelines of Lake Huron and Lake Michigan, in a band from Drummond Island to Cedarville, west to Seul Choix Point on the Garden Peninsula. Alvar also occurs further west and inland along the Escanaba River. In the Lower Peninsula, alvars occur on Thunder Bay Island and along the Lake Huron shoreline near Rogers City, Alpena, and Thompson's Harbor. In Michigan, alvars are found in subsections 212Hi, 212Rd, 212Re, and 212Rc. In Wisconsin, alvars are found on the Door Peninsula, subsection 212Tf.

Biophysical Site Description
Alvar is a biologically distinct geological feature associated with Silurian, Ordovician and Devonian limestone and dolomite bedrock occurring along the Niagara escarpment and cuestra of the Laurentian Great Lakes.

In Michigan, alvars are commonly found near northern Great Lakes shores where flat bedrock pavement associated with the Niagara Escarpment is exposed (Albert et al. 1997a, 1997b). The bedrock of the Niagara Series is Silurian age limestone and dolostone formed from marine reefs that were common in shallow portions of the Michigan Basin (Ehlers 1973); all sites on the northern shore of Lake Michigan, including the Escanaba River and Garden Peninsula alvars, are of Silurian age. This formation typically dips gently (average 1% slope) toward the south into the Michigan Basin. Ordovician age limestone and dolomite also support these plant communities on northern Drummond Island, while Devonian-age limestone occurs in Presque Isle and Alpena counties in lower Michigan. Being formed from marine organisms, these rocks are rich in calcium carbonates. Resistance to erosion is variable; limestone and dolostone are readily dissolved by rain water, producing solution cracks or grykes that often connect to the underlying groundwater system. In contrast, argillaceous limestone rich in sand, silt, or clay from terrestrial sources is more resistant to solution and typically contains few broad cracks. The proximity of alvars to the Great Lakes results in moderated climate and high precipitation.

Alvar is characterized by shallow soil over bedrock, with soil depth usually <25cm. Soil texture is primarily loamy sand or sandy loam. Soil is saturated, or locally inundated in the spring, but it becomes droughty later in the summer. Thin layers of organic soil may develop in shallow depressions that remain wet for longer periods. The soils and substrate are neutral to slightly alkaline (pH 6.7-8.0).

Vegetation Description

Alvars are dominated primarily by grasses and sedges, with mosses and lichens dominant in the driest areas, and scattered shrubs and occasionally trees in areas where the soil depth is greatest or where cracks or grykes provide additional moisture needed by woody vegetation (Reschke et al. 1999). Several different alvar communities are described on the basis of drainage differences, ranging from "tufted hairgrass wet alvar grassland" on the wettest sites to "juniper alvar shrubland" on the driest sites, which never flood (Reschke et al. 1999). Dominant grasses and sedges include *Schizachyrium scoparium* (little bluestem), *Sporobolus heterolepis* (prairie dropseed) and *Carex scirpoidea* (bulrush sedge). Where soil-water availability is greater, *Eleocharis compressa* (flattened spike-rush), *Andropogon gerardii* (big bluestem), *Muhlenbergia richardsonis* (mat muhly) and *Spartina pectinata* (cordgrass) are often dominant.

The following species were present in more than 50% of five diverse alvar sites from Michigan across Canada to New York. Characteristic grasses included *Agrostis hyemale* (ticklegrass), *Bromus kalmii* (Kalm's brome), *Danthonia spicata* (poverty grass) and *Deschampsia caespitosa* (tufted hairgrass). Sedges include *Carex crawei* (Crawe's sedge), *C. richardsonii* (Richardson's sedge), *C. scirpoidea* (bulrush sedge) and *Eleocharis elliptica* (golden-seeded spike-rush). Herbs included *Antennaria neglecta* (small-leaved pussytoes), *Aquilegia canadensis* (wild columbine), *Arabis hirsute* (hairy rock cress), *Arenaria stricta* (rock sandwort), *Campanula rotundifolia* (harebell), *Castilleja coccinea* (Indian paintbrush), *Cerastium arvense* (field chickweed), *Comandra umbellate* (bastard-toadflax), *Lepidium virginicum* (common peppergrass), *Monarda fistulosa* (wild bergamot), *Potentilla arguta* (prairie cinquefoil), *Ranunculus fascicularis* (early buttercup), *Calaminta arkansana* (low calamint), *Senecio pauperculus* (balsam ragwort) and *Solidago nemoralis* (old-field goldenrod). Characteristic shrubs include *Juniperus communis* (common juniper), *Potentilla fruticosa* (shrubby cinquefoil), *Rhus aromatica* (fragrant sumac), *Prunus virginiana* (choke cherry) and *Symphoricarpos albus* (snowberry).

Characteristic trees include *Thuja occidentalis* (northern white-cedar), *Picea glauca* (white spruce), *Pinus strobus* (white pine) and *Populus tremuloides* (trembling aspen). Cryptogram diversity (mosses, lichens, and liverworts) is also high on alvar (Marr 1997), but additional comprehensive surveys are needed.

BpS Dominant and Indicator Species

Symbol	Scientific Name	Common Name
THOC2	*Thuja occidentalis*	Arborvitae
JUCO6	*Juniperus communis*	Common juniper
CARI	*Carex richardsonii*	Richardson's sedge
DASP2	*Danthonia spicata*	Poverty oatgrass
AGROS2	*Agrostis*	Bentgrass
DECA18	*Deschampsia caespitosa*	Tufted hairgrass

POTR5	*Populus tremuloides*	Quaking aspen
PIGL	*Picea glauca*	White spruce

Species names are from the NRCS PLANTS database. Check species codes at http://plants.usda.gov.

Disturbance Description

The main disturbance in alvar systems is created by the presence of bedrock at or near the surface which results in seasonal flooding from fall through spring, often followed by summer drought in July and August, when seasonal pools dry up and vegetation is under drought stress (Reschke et al. 1999, Rosen 1995, Stephenson and Herendeen 1986). Surface temperatures can reach 43-53 deg C (109-127deg F) (Schaefer and Larson 1997, Gilman 1995). Glacial scour has created small, shallow depressions in the bedrock, which can flood either seasonally or year round, creating herb-, shrub-, or tree-dominated wetlands within the alvar landscape.

Flooding is less prevalent where there are abundant enlarged cracks (grykes) in the rock, which provide improved internal drainage. Grykes form along naturally occurring rock joints as water rich in carbon dioxide forms carbonic acid, which causes high rates of limestone dissolution. The concentration of decomposing vegetation and respiring roots in the rock joints also contributes high levels of carbon dioxide in the rock joints, accelerating the rate of limestone dissolution. Sites with many of these cracks that enhance internal drainage are more prone to early desiccation and drought. Many of the widest grykes occur under forest cover, probably because of denser rooting and large accumulations of decomposing vegetation.

Fire, both natural and human-induced, has been documented for Great Lakes alvars in both the United States and Canada (Jones and Reschke 2005, Catling and Brownell 1998), but the fire-regime is believed to be quite variable and fire is not considered important for maintaining biologically diverse alvar (Reschke et al.1999, Schaefer and Larson 1997). Grazing by native ungulates may have also been is important for reducing woody encroachment (Rosen 1992, 1995, Bengtsson et al. 1988, Titlyanova et al. 1988). Due to shallow soil, poor drainage and resultant shallow rooting of plants, windthrown trees occur on or adjacent to the alvar.

Fire Frequency

Severity	Avg FI	Percent of All Fires	Min FI	Max FI
Replacement	438	88		
Moderate (Mixed)	3222	12		
Low (Surface)				
All Fires	386	100		

Fire interval is expressed in years for each fire severity class and for all types of fire combined (All Fires). Average FI is the central tendency modeled. Percent of all fires is the percent of all fires modeled in that severity class. Minimum and Maximum FIs show the relative range of fire intervals as estimated by model contributors, if known.

Scale Description

Alvars are small to large patch systems that can include a matrix of several of the alvar community types (pavement, grassland, shrubland, glade and woodland).

Adjacency or Identification Concerns

There are several types of alvar community types: alvar pavement, alvar shrubland, alvar grassland, alvar savanna, and alvar woodlands. The model description here focuses on the alvar grassland community although VDDT model attempts to capture several of these community types including alvar pavement, alvar grassland and alvar glade and alvar woodland. The patterning of alvar pavement, grassland, shrubland, savanna, and woodland on the landscape is dependent on amount of soil development over bedrock, drainage conditions, and proximity to seed sources. Therefore although these community types may occur together in a matrix setting - they are not exactly successional classes of each other within the time frame of the model. The distribution and patterning of these community types are controlled much more by abiotic factors than by successional and disturbance factors.

Principle threats to alvar communities are over-grazing, alteration of hydrology with road construction and off-road vehicle use, construction of summer residences within the open grassland and quarry development (Reschke et al. 1999).

Issues or Problems

See adjacency/identification concerns section.

Native Uncharacteristic Conditions

Comments

Succession Classes

Mapping Rules

Upper Layer Lifeform	Height (m)	Canopy Cover (%)									
		0-10	11-20	21-30	31-40	41 - 50	51-60	61-70	71-80	81-90	91-100
Herb	0-0.5	A	A	A	A	A	A	A	A	A	A
Herb	0.5-1.0	A	A	A	A	A	A	A	A	A	A
Herb	>1.0	A	A	A	A	A	A	A	A	A	A
Shrub	0-0.5	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Shrub	0.5-1.0	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Shrub	1.0-3.0	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Shrub	>3.0	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Tree	0-5	B	B	B	B	UN	UN	UN	UN	UN	UN
Tree	5-10	UN	UN	UN	UN	C	C	C	C	C	C
Tree	10-25	UN	UN	UN	UN	C	C	C	C	C	C
Tree	25-50	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN
Tree	>50	UN	UN	UN	UN	UN	UN	UN	UN	UN	UN

Succession class letters A-E are described in the Succession Class Description section. Some classes use a leafform distinction where a qualifier is added to the class letter: Brdl (broadleaf), Con (conifer), or Mix (mixed conifer and broadleaf). UN refers to uncharacteristic native or a combination of height and cover that would not be expected under the reference condition. NP refers to not possible or a combination of height and cover which is not physiologically possible for the species in the BpS.

Description

Class A 45 **Early Development 1 - All Structures**

Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position

JUCO6	Juniperus communis	Common juniper	Low-Mid
SCHIZ4	Schizachyrium	Little bluestem	Lower
DASP2	Danthonia spicata	Poverty oatgrass	Lower
ELCO2	Eleocharis compressa	Flatstem spikerush	Lower

Description
Alvar pavement and grassland phase: This stage is the essentially a grassland that occurs on thin soils over bedrock. Grasses include *Schizachyrium scoparium* (little bluestem), *Danthonia spicata,* (poverty oat grass), *Panicum* spp (panic grass), and *Carex* spp (sedges). Seasonally wet these grasslands may also support species such as tufted hairgrass (*Deschampsia caespitosa*), spikerush (*Eleocharis compressa*), cordgrass (*Spartina pectinata*) and rushes (*Juncus* spp.) (Catling and Brownell 1995). Interspersed within an alvar grasslands may be open areas of exposed bedrock (pavement) where vegetation is restricted to grykes.

Abiotic factors (such as the proximity of bedrock to the soil surface) combined with seasonal flooding and drought limit the encroachment of trees and shrubs into the alvar grassland system, yet as soil development increases (a time scale not modelable for LANDFIRE) trees and shrubs will be able to establish moving this system to an alvar glade. Alternate succession was used to model the transition from alvar grassland to alvar glade. Seasonal flooding (spring) followed by summer drought was modeled as "optional 1". Also, replacement fires may burn through alvar grasslands (Jones and Reschke 2005).

Maximum Tree Size Class
None

Class B 40 Mid Development 1 - Open

Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position
PIGL	Picea glauca	White spruce	Upper
BEPA	Betula papyrifera	Paper birch	Upper
THOC2	Thuja occidentalis	Arborvitae	Upper
ABBA	Abies balsamea	Balsam fir	Upper

Description
Alvar galde (limestone-bedrock glade) phase: This is an herbaceous and graminoid dominated community with scattered clumps of stunted trees and shrubs. Tree cover >10%, shrub cover >25%. Dominant trees include white spruce (*Picea glauca*), paper birch (*Betula papyrifera*), northern white cedar (*Thuja occidentalis*) and balsam fir (*Abies balsamea*). Tree height is typically <20ft (6m). Common shrubs include soapberry (*Shepherdia canadensis*) and bearberry (*Arctostaphylos uva-ursi*). Common herbs are Canada mayflower (*Maianthemum canadense*), wild strawberry (*Fragaria virginiana*), balsam ragwort (*Senecio pauperculus*), and large-leaved aster (*Aster macrophyllus*). Poverty grass (*Danthonia spicata*), slender wheat grass (*Agropyron trachycaulum*) and bracken fern (*Pteridium aqualinum*) are also common. (Albert 2006b).

Alvar glade develops in areas of greater soil development or better drainage than the alvar grassland community. Succession from class A could result in the development of this class (alvar grassland succeeding to alvar glade) but the timescale for sufficient soil development is beyond the scope of this model. Therefore, the transition to this phase was modeled using alternate succession. In class B seasonal flooding (spring) followed by summer drought was modeled as "optional 1". Also, replacement fires would kill the scattered trees and shrubs of this stage. Native grazing by white-tailed deer would maintain this class by restricting tree development. Alternate succession would take the system from the alvar glade to the alvar woodland stage. Again woodland development would depend largely on amount of soil development over bedrock.

Areas of alvar pavement, or exposed bedrock, may also occur as small to large patches within an alvar glade.

Maximum Tree Size Class
Medium 9-21"DBH

Class C 15 Late Development 1 - Closed

Indicator Species

Symbol	Scientific Name	Common Name	Canopy Position
THOC2	Thuja occidentalis	Arborvitae	Upper
BEPA	Betula papyrifera	Paper birch	Upper
PIGL	Picea glauca	White spruce	Upper
ABBA	Abies balsamea	Balsam fir	Upper

Description
Alvar woodland (closed forest over limestone bedrock) The species composition of this stage would be similar to the alvar glade but tree canopy would exceed 30% and groundcover would be patchy with a higher dominance of sedges and forbs.

A mixed fire would convert the woodland back to a glade stage, a replacement fire would take the system back to a grassland.

Maximum Tree Size Class
Large 21-33"DBH

Model Parameters

Deterministic Transitions

From Class	Begins at (yr)	Succeeds to	After (years)
Early1:ALL	0	Early1:ALL	999
Mid1:OPN	1	Mid1:OPN	999
Late1:CLS	2	Late1:CLS	999

Probabilistic Transitions

Disturbance Type	Disturbance occurs In	Moves vegetation to	Disturbance Probability	Return Interval (yrs)	Reset Age to New Class Start Age After Disturbance?	Years Since Last Disturbance
Alternative Succession	Early1:ALL	Mid1:OPN	0.002	500	Yes	0
Replacement Fire	Early1:ALL	Early1:ALL	0.003	333	Yes	0
Optional 1	Early1:ALL	Early1:ALL	0.5	2	No	0
Alternative Succession	Mid1:OPN	Late1:CLS	0.001	1000	Yes	0
Replacement Fire	Mid1:OPN	Early1:ALL	0.002	500	Yes	0
Native Grazing	Mid1:OPN	Mid1:OPN	0.01	100	No	0
Optional 1	Mid1:OPN	Mid1:OPN	0.5	2	No	0
Replacement Fire	Late1:CLS	Early1:ALL	0.001	1000	Yes	0
Mixed Fire	Late1:CLS	Mid1:OPN	0.002	500	Yes	0

Optional Disturbances
Optional 1: spring flooding/summer drought

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