ELEMENT STEWARDSHIP ABSTRACT
for

*Rhamnus cathartica, Rhamnus frangula (*syn. *Frangula alnus*)

Buckthorns

To the User:

Element Stewardship Abstracts (ESAs) are prepared to provide The Nature Conservancy's Stewardship staff and other land managers with current management-related information on those species and communities that are most important to protect, or most important to control. The abstracts organize and summarize data from numerous sources including literature and researchers and managers actively working with the species or community.

We hope, by providing this abstract free of charge, to encourage users to contribute their information to the abstract. This sharing of information will benefit all land managers by ensuring the availability of an abstract that contains up-to-date information on management techniques and knowledgeable contacts. Contributors of information will be acknowledged within the abstract and receive updated editions. To contribute information, contact the editor whose address is listed at the end of the document.

For ease of update and retrievability, the abstracts are stored on computer at the national office of The Nature Conservancy. This abstract is a compilation of available information and is not an endorsement of particular practices or products.

Please do not remove this cover statement from the attached abstract.

Authors of this Abstract:
Carmen K. Converse

The Nature Conservancy
Element Stewardship Abstract
For *Rhamnus cathartica, Rhamnus frangula (*syn*. Frangula alnus)*

I. IDENTIFIERS

Common Name: Buckthorn, Common Buckthorn (*R. cathartica*)
Glossy Buckthorn, Fen Buckthorn, Alder Buckthorn (*R. frangula*)

General Description:
R. cathartica is a deciduous shrub or small tree two to six meters tall (Rosendahl 1970). Dull green leaves are ovate-elliptic, glabrous and minutely serrate. Leaf arrangement is alternate or subopposite (Barnes and Wagner 1981). Gray-black bark and twigs have prominent lenticels. Glabrous twigs may be tipped with sharp stout thorns (Rosendahl 1970). Two to six greenish-yellow flowers, having four petals are born in axillary umbels and are fragrant (Barnes and Wagner 1981).

R. frangula is a shrub or small tree growing to seven meters (Rosendahl 1970). Brown-green branches have elongate lenticels, and may be slightly pubescent (Soper and Heimburger 1982). Thin glossy leaves are obovate or elliptic with entire or obscurely crenulate margins. They are glabrous or slightly pubescent beneath and are usually alternate. Yellowish-green five parted perfect flowers are born in sessile umbels.

II. STEWARDSHIP SUMMARY

III. NATURAL HISTORY

Habitat:
Range: R. cathartica is native to most of Europe except Iceland and Turkey; and grows in west and north Asia. R. frangula is native to North Africa, Asia, and Europe, except Iceland (Bailey 1976, Polunin 1969).

In North America, R. cathartica is naturalized from Nova Scotia to Saskatchewan, south to Missouri and east to Virginia (Soper and Heimburger 1982). R. frangula occurs from Nova Scotia to Manitoba, south to Minnesota, Illinois, New Jersey (Soper and Heimburger 1982) and Tennessee (Kral 1981).

Native Habitat (Europe/Asia): Native habitats of R. cathartica are diverse and include the understory of open oak (Leitner 1984, Tansley 1968), oak-beech, or ash woods (Tansley 1968, Hinneri 1972). It also occurs in riverine woods (Leitner 1984, Tansley 1968), thickets on exposed rocky sites (Hinneri 1972), hedgerows (Eldin 1968, Polunin 1969), pastures (Polunin 1969, Tansley 1968, Duffey et al. 1974) and alkaline shrub carr fens (Godwin and Bharucha 1932, Tansley 1969). It grows in well-drained sand, clay, or poorly drained calcareous soils, but prefers neutral or alkaline soils. It is less vigorous in dense shade, and may grow on woodland edges in sunny southern or western exposures (Leitner 1984).

R. frangula typically inhabits wetter, less shaded, and more acidic soils than R. cathartica (Tansley 1968). It grows in soils of any texture (Sukachev 1928). Habitats include alder thickets (Eldin 1968, Tansley 1968) and calcareous wetlands (Godwin and Bharucha 1932, Tansley 1968). Heath-oak woods (Tansley 1968), pine (Kornev 1952) and spruce (Sukachev 1928) woods frequently have R. frangula in the understory. R. frangula is recommended for reforestation of degraded European sites having water-logged, podzolized clay soils low in available nutrient and humus (Ziani 1957).

North America: These species were probably introduced to North America before 1800 (Wyman 1971), but did not become widespread and naturalized until the early 1900s (Howell and Blackwell 1977). They are cultivated for hedges (Wyman 1971), forestry uses, and wildlife habitat. R. cathartica is used in

shelter belt planting (Hubbard 1974). Naturalized habitats include pastures, fencerows, roadsides, and slopes of ravines.

Reproduction:
Natural reproduction is primarily sexual; asexual means are absent or insignificant.

Plants of both species reach seed bearing age quickly (Godwin 1936). Flowers of R. cathartica may be polygamous, but are usually dioecious (Barnes and Wagner 1981) and bloom May through June during leaf expansion (Fernald 1950). R. frangula blooms in late May through September, after leaf expansion (Malicky et al. 1970). Flowers of R. frangula can blossom on current season's growth (Gleason and Cronquist 1963). In one known case, R. frangula bloomed and produced fruit on resprouts the same season it was cut (Brue 1980).

The globose black drupes of R. cathartica ripen in August through September, and each contains three or four grooved seeds. The subglobose drupes of R. frangula are red turning to black. They ripen in July through August and have two or three ungrooved seeds (Fernald 1950). Fruit production of both species is abundant each year (Hubbard 1974), but R. cathartica is apparently more productive than R. frangula (Lovely 1983, Hasselkus 1983).

Dispersal: Fruit of both species is efficiently dispersed usually by starlings, blackbirds, woodducks, elk, mice (Ridley 1930), cedar waxwings, robins and blue jays. Mice are also seed predators (Godwin 1936). Apparently, few bird species readily tolerate the anthranquinones (emodin) present especially in the immature fruit, preventing premature dispersal (Trail and Dimond 1979). R. cathartica retains fruit into, or throughout, the winter, whereas fruit of R. frangula more rapidly falls to the ground following ripening (Godwin 1936).

Because R. cathartica fruit is retained on the plant longer and is therefore more visible to birds, seeds may be dispersed more frequently over longer distances than seeds from R. frangula.

The importance of water dispersal is unknown, but dry fruit of R. cathartica can float six days and seeds float three days before sinking. Fresh fruit of R. frangula floats 19 days, and dry seed floats one week (Ridley 1930). This dispersal could be significant in areas of frequent and extensive fall and winter flooding.

Horticultural distribution of both species increases seed sources for dispersal by the above vectors.

Establishment: Germination of both species varies because seeds have either embryo or seed coat dormancy or both require stratification and scarification (Godwin 1936, Hubbard 1974, Tyszkiewicz and Dabrowska 1953). This variability is not necessarily consistent within a species (Hubbard 1974) such that germination could be opportunistic.

Seedling Establishment: Although seedlings invade apparently stable habitats, recruitment is most successful where there is ample light (Leitner 1984, Kowlaski 1968) and exposed soil (Andreas 1983). Tests of R. cathartica seedlings grown under various densities and light intensities showed reduced growth as shade increased (Leitner 1984). In a reforestation project, R. frangula seedling success was greater in areas where previous vegetation was removed and soil cultivated, than in areas burned, lightly raked, or untreated prior to seedling (Bodeux 1958).

R. frangula seedling density is usually high near seed sources (Godwin 1936, Andreas 1983, Pauly 1983). In one invaded area, seedling density averaged almost 54 per 0.1 m2 quadrant (Brue 1980).

These buckthorns have long growing seasons, rapid growth rate, and resprout vigorously following top removal. Alteration of dormancy growth rhythms in Rhamnus spp. is not significantly related to thermo- or photoperiods (Lavarenne et al. 1971). In North America, both species leaf out prior to most woody

deciduous plants; R. cathartica in late April to mid-May, and R. frangula in mid to late May (Malicky et al 1970). They retain leaves in late September through October and sometimes into November (Hanson and Grau 1979, Lovely 1983). Leafdrop possibly occurs earlier in open areas than in shade (Pauly 1984). In Europe, shoot growth of R. frangula appears to be greatest in the earlier part of the season (Raulo et al. 1975).

Plants of R. frangula `columnaris' of 0.7 m in height, are capable of growing about 4 m in five years (Wyman 1971). Mature plants, cut near the base early in the season can send up sprouts up to 2 m tall in the same year (Wyman 1971, Andreas 1983, Brue 1980). In one case, a plant with stems seven to eleven cm in diameter at the base sent up to 50 sprouts following cutting (Wyman 1971).

Buckthorns rapidly form dense, even-aged thickets. In an open site, buckthorn establishment is followed by lateral crown spread. This extension continues until branches touch adjacent shrubs. The large leaves and continuous canopy create dense shade. In Wicken Fen, Godwin (1936) found that a mixed sedge area colonized by R. frangula seedlings became continuous shrub carr in about 20 years. Even-aged thickets are common in both wetlands and in woodland understories.

The vigor of both species is often related to light availability. It seems that seedlings of R. cathartica establish readily under partial light and those of R. frangula under full light. As plants mature, R. frangula shows less shade tolerance than does R. cathartica. For example, it shades out its lower leaves and assumes a more columnar growth habit in dense thickets, while R. cathartica may retain lower leaves in its own shade (Godwin 1936). Seedlings of both species may become established, but show little growth under adult plants. Thickets may be even-aged because Rhamnus seedlings are repressed.

Adult plants of R. frangula can be temporarily suppressed by canopy species. In a 50 year study of pine stands in Russia, R. frangula decreased in the understory as canopy cover increased. However, as pines matured and cover density decreased, R. frangula renewed vigorous growth mostly by basal sprouting (Kornev 1952).

Buckthorn affects the survival of co-occurring species. Other woody plants such as Viburnum opulus L. (in Europe) and Betula pumula L. may be replaced by buckthorn, or are unable to invade buckthorn thickets (Godwin 1936, Lovely 1982).

The effects of buckthorn on herbaceous vegetation is uncertain. In Wicken Fen, dense thickets of both species altered herbaceous understory composition (Godwin et al. 1974). Cypripedium candidum Muhl. crown production decreased in the shade of woody plants including R. frangula in a Wisconsin fen (Lovely 1981). In an oak woods study, R. cathartica did not significantly alter herbaceous ground cover composition, but did limit growth of other woody seedling species (Leitner 1984, Brue 1980).

IV. CONDITION

V. MANAGEMENT/MONITORING

Management Requirements:
Management problems: In addition to the above naturalized habitats, these species are problems in parts of some natural areas. R. cathartica invasion is greatest in selectively cut or grazed woods (Leitner 1984), along woodland edges, in openings created by windfalls or deadstands because of canopy tree disease (Farrar 1983) or in thickets growing within prairies (Kline 1983). Open oak woods (Kline 1983, Ware 1983), and lowland woods (Swink 1974) are typically invaded; sugar maple woods are less frequently invaded (Leitner 1984). Fire suppression along the prairie forest border has possibly increased invasion in open woods and adjacent prairie (Leitner 1984). R. cathartica tolerance of heavy clay soils, and moist or dry sites increases its success in some of the above habitats.

R. frangula sometimes invades similar woodland habitats (Brue 1980), but more often invades wetlands that are comparable to its European wetland habitats. North American wetlands invaded by glossy buckthorn include wet prairies, marshes, calcareous fens (Bacone 1983), sedge meadows (McClain 1983, Packard 1983), sphagnum bogs (Howell and Blackwell 1977, Swink 1974) and tamarack swamps (Hasselkus 1983, Swink 1974). In these wetlands, somewhat drier conditions that are more conducive to woody plant growth, are increased by water manipulation including drainage (ditches, roads, sluices) and water table reduction (Harris and Marshall 1963, Vogl 1969, Forsyth 1974, Zimmerman 1978, Moran 1981, Lovely 1981, Gawler 1983). R. frangula is most successful under drier conditions in wetlands. In Wicken Fen of England, Godwin and Bharucha (1932) found that although Rhamnus spp. grew in the same position relative to the water table as did mixed sedge communities, its growth was limited by high winter water levels. As drainage increased, drier conditions resulted in Rhamnus dominance (Godwin et al. 1974).

Other possible reasons for invasion of wetlands include:
1. Acidification of surface peat of calcareous fens (Godwin 1974).
2. Exposed mineral soil providing a seed bed (Andreas 1983).
3. Fire supression and cessation of routine mowing (Godwin 1936, Curtis 1946, Vogl 1969, Godwin et al. 1974, White 1965, Zimmerman 1978, Moran 1981, Gawler 1983).

Composition, especially of upland deciduous woods and of wetlands may be altered because of invasion of R. cathartica and R. frangula. These species are invasive for the following reasons:

1. They became widespread in North America when various disturbances (drainage, lack of fire, woodland grazing and cutting, etc.) created ideal habitat for seedling recruitment and maintenance of sexually mature adults.
2. Naturalized habitats are similar to indigenous habitats.
3. Seed production, dispersal and germination are effective.
4. Adult plants form dense colonies, have large shading leaves, and are persistent.
5. Plants vigorously resprout after top removal.

Cultural controls include cutting, mowing, girdling, excavation, burning, and "underplanting."

Cutting/Mowing: Repeated cutting reduces plant vigor. In a Wisconsin calcareous fen, R. frangula, cut manually twice in one season (early June and late August) for two or three successive years, had fewer and shorter stems than a control (Lovely 1983). Growth was similar in plots cut only once a year for the same periods, but herbaceous groundcover was most vigorous in plots cut twice a year (Lovely 1983). R. frangula cut in late September may resprout the same season (Ohio) (Andreas 1983). In one case, techniques of double cutting within several hours of the same day did not control growth of R. cathartica (Coenen 1983). R. frangula mowed closely (2 to 13 cm from ground) once or twice in June or July, survives as small plants (Bristol 1983) or vigorous resprouts (Brue 1980). Mowing maintains open areas by preventing seedling establishment (Curtis 1946, Godwin 1936).

Girdling: R. frangula completely encircled at the base by a two to three cm wide saw cut into the phloem, do not resprout (Reed 1983). Girdling may be done all winter, does not disrupt the soil, nor adversely affects sensitive wetlands. A five second flame torch application around the stem will kill the cambium of stems less than 4.5 cm in diameter (Reed 1983).

Excavation: Seedlings or small plants may be hand pulled or removed with a grubbing hoe (Kline 1983, Bacone 1983, Andreas 1983, Brue 1980) or larger plants may be pulled out with heavy equipment (Bristol 1983, Brue 1980). Excavation often disturbs roots of adjacent plants, or creates open soil readily colonized by new seedlings (Bacone 1983). This technique may be most useful to control invasion at low densities, or along trails, roads, and woodland edges.

Burning: Presently most fire treatments do not control Rhamnus spp. Some data indicate limited effective use of fire management in a recovery phase. The season of a burn and vegetation of the area to be burned most influence this phase of fire management. Because Rhamnus leafs out earlier than most native species, a late April or early May burn in the upper midwest (Wisconsin, Illinois, Michigan) potentially top kills Rhamnus. Because carbohydrate levels are low in roots at this time, resprouting vigor may be reduced. In a Michigan fall burn of a calcareous fen, stem density of R. frangula was twice as great the following summer than before the burn. Resprouts were one-third the height of the pre-burn stems (Kohring 1978).

If herbaceous vegetation exists beneath Rhamnus, fire effectively top-kills shrubs especially during dry weather (Godwin 1936). In most cases, however, groundcover is sparse beneath large shrubs or dense thickets, preventing fire spread unless conditions are dry and/or windy (Packard 1983). Resprouting usually follows top-kill, especially in wetlands where moisture protects the basal crown (Godwin 1936). Harty (1983) found that burning an oak savanna on a two year rotation for R. cathartica control resulted in resprouting.

A burning schedule to maintain vigor of native vegetation possibly prevents easy seedling establishment, unless seed sources are nearby.
If seed sources are near burned areas, fire-exposed soils or peat probably are more readily invaded by seedlings than groundcover of unburned areas (Lampa 1984). In some wetlands, lack of flooding following burning has been shown to increase general woody plant invasion (Vogl 1969).

Underplanting: "Underplanting" disturbed woods with native woody species is potentially effective to prevent primary invasion, or re-invasion of Rhamnus spp. Sugar maple (Acer saccharum Marsh.) seedlings have been planted in oak woods of the Morton Arboretum Illinois (Ware 1983), and the University of Wisconsin Arboretum (Kline 1983). Seedling success was poor in the Illinois planting. In Wisconsin, sugar maple that were 2 to 3 feet (0.7 to 0.9 m) up to 8 feet (2.4 m) tall in 1946 when planted, are 4 in. (10.2 cm) dbh (diameter breast height) and have basal areas of 0.8 sq. dm. The most invasive species in this planting has been red maple (A. rubum L.).

Chemical: The following table summarizes chemical treatment. Best control possible results from the following treatments:
1. Stump application of 20% glyphosate in August/September (Kline 1983).
2. Wick application of 2-1/2 - 3% glyphosate in May (Lampa 1983).
3. Mist application of 2.4 kg/ha fosamine (ammonium salt) in September (Niehuss and Roediger 1974).
4. Frill application of Picloram (ready to use) during the growing season (Farrar 1983).
5. Basal application of 2,4-D in diesel fuel at 2-4% (Sannikov and Tykvina 1971) or 12.5% (Kline 1983) during the first half of the growing season.

Some special features of herbicide use are as follows:
1. Without a surfactant, glyphosate should not harm non-target vegetation or surrounding watersheds when used in anaerobic situations. It will degrade more slowly in anaerobic than aerobic conditions (Jackson 1984).
2. Effectiveness of fosamine (ammonium salt) may be related to downward translocation of plants preparing for dormancy (Niehuss and Roediger 1974).
3. Picloram + 2,4-D is soil mobile and probably affects non-target vegetation in certain areas (Farrar 1983).
4. If 2,4-D is carefully applied, there is no known damage to surounding plants or soil fauna (Nat. Conservancy, Great Brit. 1962). Basal applications must completely encircle the trunk to be effective (Pauly 1983).

The following tabulates control efforts used against Rhamnus, and follows the format:
Reference and species targeted; Application Rate; Application Method; Application Time; Geographic Location; Results.

Trials using 2,4-D

Sannikov & Tykvina 1971, Rhamnus sp.; 2-4% ester w/diesel fuel; basal painting up to 10 cm basal diameter; first half growing season; USSR; 100%

Pauly 1983, Rhamnus sp.; 4% ester w/diesel fuel; basal spray; ???; WI; good control if completely encircles trunk.

Pauly 1983, Rhamnus sp.; 4% ester w/diesel fuel; stump; ???; WI; control.

Rohrig 1953, R. frangula; 0.2-0.9% ester aqueous; foliar, hand sprayed; Mar-Aug; Germany; Poor, defoliated growth reflush.

Parsons 1983, R. frangula; 1--1.5% diesel fuel surfactant; foliar, tractor sprayer; growth flush; OH; some control of resprouts following mowing.

Kline 1983, R. cathartica; 12.5% in diesel fuel; basal; ???; WI; 100%

(some used a combination of 2,4-D + 2,4-DP, each as 21.9% acid equivalent or 2 lbs/gal

Trials using AMS:

Packard 1983; aqueous as concentrated as possible; stump painting; year-round; IL; control. Best control on fresh cuts.

Trials using glyphosate:

Lampa 1983, R. frangula; 2.5-3%; wick; May-June; IL; 90-100% control.

Chapman 1983, R. frangula; 10%; mist bottle, stumps less than 5 cm dbh; August; MI; control.

Chapman 1983, R. frangula; 10%; mist bottle, stumps greater than 12 cm dbh; August; MI; resprouting Sept.

Kline, 1983 (Res. Mgmt. Notes), R. cathartica; 20%; stump; Aug/Sept; WI; 100% control

Ware, 1983, R. cathartica; ???; stump (cut fall or spring); bud-break to June; IL; control.

Trials using Fosamine

Pauly 1983, Rhamnus sp.; 4%; mist sprayer, seedlings; mid-late summer; WI; 60-70%. Recommend for fall (Oct) application.

Niehuss, 1974, R. frangula; 2.4 kg/ha; mist sprayer; Sept; Great Britain; 97.5% control after 1 year.

Trials using Picloram (25%)+2,4-D (75%)

Pauly, 1983, Rhamnus sp.; ready to use; squirt bottle stump; summer; WI; good control.

Farrar, 1983, R. cathartica; ???; paint into frills; ???; IA; 100%. Some damage to nontarget species.

Combination: Combined methods may increase control. In fens, Lovely (1983) suggests cutting R. frangula in the spring at leaf expansion and again in the fall, followed by spring burning the next two years. Combining cutting with herbicide use may control Rhamnus when burning conditions are poor or

where burning increases Rhamnus invasion. Resprouts resulting from cutting or mowing probably are highly susceptible to translocatable herbicides because of decreased distance to roots, and greater absorbtion by young shoots. Depletion of root carbohydrates may increase transfer rates of food (and herbicides) to roots (Leonard 1963).

Biological Control: R. cathartica and R. frangula are alternate hosts for oat rust (Puccina coronata) (Hanson and Grau 1979). Because North American insects do not readily feed on buckthorn (probably because of emodin), many host specific European insects of the Rhamnaceae were evaluated for potential Canadian introduction to control buckthorn (Malicky et al. 1970). Because R. cathartica is agronomically a worse pest, and is of less ornamental value than R. frangula, further studies have been limited to R. cathartica pests including Scotosia vetulata Schiff. and Triphos dubiata L. (Malicky et al. 1970). Results are unknown.

In England, R. frangula declined when diseased by Fusarium and Nectria fungi (Godwin 1936). An attempt to simulate this decline was initiated in Wisconsin by Rhamnus inoculation of Triocothecum roseum, a fungus potentially causing root rot (Brue 1980). No results are available.

VI. RESEARCH

Management Research Programs:
States where this is being managed and some contacts:

Illinois:

Fran Harty
Illinois Dept. of Conservation
Forestry and Natural Heritage NE Illinois
No. 8 Henson Place
Champaign, IL
217/333-5773

Wayne Lampa
Resource Naturalist Specialist
DuPage Co.
Forest Preserve Dist.
Wheaton, IL
312/790-4900

Steve Packard
The Nature Conservancy
Illinois Field Office
79 West Monroe St., Suite 708
Chicago, IL 60603
312/346-8166

George Ware
Research Director
Morton Arboretum
Lisle, IL 63502
312/968-0074

Indiana

John Bacone

Director of Division of Natural Preserves
Indiana Dept. of Natural Resources
601 State Office Bldg.
Indianapolis, IN 46204
317/232-4052

Iowa

Donald R. Farrar
Associate Professor
Department of Botany
Bessey Hall
Ames, IA 50011
515/294-4846

Ohio

Barb Andreas
216/292-2389

Michigan

Kim Chapman
Department of Biology
Western Michigan University
Kalamazoo, MI 49008
517/373-1552

Wisconsin

Virginia Kline
Ecologist
University of Wisconsin-Madison
Arboretum
1207 Seminole Hwy.
Madison, WI 53711
608/263-7344 or 608/262-2179

Wayne Pauly
Dane Co. Naturalist
Dane Co. Hwy. Dept.
2302 Fish Hatchery Rd.
Madison, WI 53713
608/266-5922

Don Reed
Principle Biologist
SE Wisconsin Regional Planning
Box 162
Waukesha, WI
414/547-6721

VII. ADDITIONAL TOPICS

VIII. INFORMATION SOURCES

Bibliography:

Andreas, Barb. 1983. Nov. 30. Botanist. Telephone conservation with C. K. Converse, The Nature Conservancy, Midwest Regional Office.

Bacone, John. 1983 Nov. 29. Director, Div. Nat. Preserves, Indiana Dept. Nat. Res. Telephone conversation with C. K. Converse, The Nature Conservancy, Midwest Regional Office.

Bailey, L.H. 1976. Hortus Third: A concise dictionary of plants cultivated in the United States. New York: McMillan Publishing Co.

Barnes, B.V.; Wagner, W.H. Jr. 1981. Michigan Trees. Ann Arbor: The University of Michigan Press. 384 p.

Bennett, J.M. 1960. Weeds and brush in non-crop land. Research Report East Section National Weed Comm. Canada. pp. 86-89.

Bodeux, A. 1957. (The Campine Calluna heaths and conditions for their afforestation.) (French) Repr. from Revue de l'Agricuture 1960 (abstract no. 456).

Bristol, Peter. 1983 Nov. 30. Horticulturist, Holden Arboretum, Mentor, Ohio. Telephone conversation with C.K. Converse, TNC, MRO. The Nature Conservancy, Midwest Regional Office.

Brue, J.A. 1980. Conversion of buckthorn (Rhamnus frangula) thickets to Canada goose grazing and loafing areas of the Bay Beach Wildlife Sanctuary Part II. Green Bay, WI: University of Wisconsin; graduate credit project.

Chapman, Kim. 1983 Dec. 6. Heritage Botanist, Michigan. Telephone conversation with C.K. Converse, The Nature Conservancy, Midwest Regional Office.

Coenen, Linda. 1983 Nov. 29. Graduate student, Univ. WI-Madison. Telephone conversation with C.K. Converse, The Nature Conservancy, Midwest Regional Office.

Curtis, J.T. 1946. Use of mowing in the management of white lady slipper. J. Wildlife Management 10: 303-308.

Duffey, E.; Morris, M.G.; Sheail, J.; Ward, L.K.; Wells, T.C.E. 1947. Grassland Ecology and Wildlife Management. London, England: Chapman and Hall, Ltd. 281 p.

Eglite, A. and Zile, M. 1957. (Destroying trees and shrubs with 2-4-D and 2,4,5-T Na salts.) (Latvian) Latvijas PSR Zinatnu Akademijas Vestis, Riga No. 3. Taken from: Forestry Abstr. 20(2): 246; 1959 (Abstract No. 1958).

Eldin, H.L. 1968. A modern sylva or a discourse of forest trees: The smaller native broadleaved trees. Quarterly J. Forestry 62(1): 28-36.

Farrar, Donald. 1983 Dec. 15. Assoc. Prof. Botany, Iowa State Univ., Ames, IA. Letter to C.K. Converse, The Nature Conservancy, Midwest Regional Office.

Fernald, M.L. 1950. Gray's Manual of Botany. 8th ed. New York: D. Van Nostrand Co.

Forsyth, J.L. 1974. Geologic conditions essential for the perpetuation of Cedar Bog, Champaign County, Ohio. Ohio J. of Sci. 74(2): 116-125.

Gawler, S.C. 1983. Shrub invasion in fens: a literature review. Madison, WI, Univ. WI; 13 p. Wetland ecology class paper; Dept. Landscape Architecture.

Gleason, H.A.; Crouquist, A. 1963. Manual of vascular plants of northeastern United States and adjacent Canada. New York: Van Nostrand Reinhold Co. 810 p.

Godwin, H. 1936. Studies in the ecology of Wicken Fen III: The establishment and development of fen scrub (carr). J. Ecology 24: 82-116.

Godwin, H.; Bharucha, F.R. 1932. Studies in the ecology of Wicken Fen II. The fen water table and its control of plant communities. J. Ecology 20(1): 157-191.

Godwin, H.; Clowes, D.R.; Huntley, B. 1974. Studies in the ecology of Wicken Fen V. Development of fen carr. J. Ecology 62: 197-214.

Hanson, E.W.; Grau, C.R. 1979. The buckthorn menace to oat production. Publication Cooperative Extension programs. WS 2000; A2860. Univ. WI Extension, Madison, WI. 2 p.

Harris, S.W.; Marshall, W.H. 1963. Ecology of water-level manipulations on a northern marsh. Ecology 44: 331-343.

Harty, Fran. 1983 Dec. 6. Illinois Dept. Conservation. Conversation with C.K. Converse, The Nature Conservancy,Midwest Regional Office.

Hasselkus, Edward. 1983 Dec. 9. Professor horticulture. Personal communication at Univ. WI, Madison.

Hinneri, Sakari. 1972. An ecological monograph on eutrophic deciduous woods in the SW archipelago of Finland. Annales Universitatis Turkuensis Ser. A.II. 131 p.

Howell, J.A.; Blackwell, W.H. Jr. 1977. The history of Rhamnus frangula (glossy buckthorn) in the Ohio flora. Castanea 42(2): 111-115.

Hubbard, R.L. 1974. Rhamnus L. In Seeds of Woody Plants in the United States. U.S. Department Agric. Forest Service Agri. Handbook 450: 704-708.

Jackson, Donald. 1984 Jan. 20. Product supervisor/Monsanto, St. Louis, MO. Telephone conversation with C.K. Converse, The Nature Conservancy, Midwest Regional Office.

Kline, Virginia. 1983 Dec. 9. Ecologist, Univ. WI Arboretum, Madison, WI. Personal communication with C.K. Converse, The Nature Conservancy, Midwest Regional Office.

Kohring, Margaret. 1978. Effect of a fall burn on Bakertown Fen, Berrien Co., MI. Located at TNC, The Nature Conservancy, Midwest Regional Office. 21 p.

Kornev, V.P. 1952. (Changes occurring in the underwood of Scots Pine stands in the course of rotation.) (Russian) Lesn. Hoz. 5(2): 65-70. Taken from: Forestry Abstr. 16(2): 187; 1955 (Abstract No. 1542).

Kowalski, M. 1968. (Effect of different degrees of stand density on the growth of seedlings of various species of trees and shrubs.) (Polish) Zesz. nauk. Szkol. Gospod. Wiejsk. Warsz (Lesn') no. 11: 17-49. Taken from: Forestry Abstr. 30(4): 658; 1960 (Abstract No. 5659).

Kral, R. 1981. Some distributional reports of weedy or naturalized foreign species of vascular plants for the southern states, particularly Alabama and middle Tennessee. Castanea 46(4): 334-339.

Lampa, Wayne. 1984 Jan. 16. Resource Management Specialist, Du Page Co., For. Preserve, IL. Telephone conversation with C.K. Converse

Lavarenne, S.; Champagnat, P.; Barnda, P. 1971. (Growth rhythm of some woody plants from temperate regions when grown in acclimatization chambers with constant high temperature and different photoperiods.) (French) Bull. de la Soc. Botanique de France. 118(3/4): 131-162. Taken from: Forestry Abstr. 34(4); 1973 (Abstract No. 2139)

Leitner, L.A. 1984 Jan. 13. Letter and summary of research with Rhamnus cathartica sent to The Nature Conservancy, Midwest Regional Office from Univ. WI-Milwaukee, BotanyDept., 5 p. + 3 figs. + one chart

Leonard, O.E. 1963. Translocation of herbicides in woody plants. Proc. Soc. Amer. Foresters, 99-103.

Lovely, D.M. 1981. Wingra Fen vegetation and hydrologic studies. Submitted to Friends of Univ. WI Arboretum, Madison, WI. 24 p.

Lovely, D.M. 1982. Wingra Fen: 1982 report. Submitted to Friends of Univ. WI Arboretum, Madison, WI. 26 p.

Lovely, D.M. 1983 Dec. 9. Personal communication at Univ. WI, Madison.

McClain, William. 1983 Nov. 11. Heritage Botanist, IL Dept. of Conservation. Telephone conversation with C.K. Converse, The Nature Conservancy, Midwest Regional Office.

Malicky, H.; Sobhian, R.; Zwolfer, H. 1970. Investigations on the possibilities of a biological control of Rhamnus cathartica L. in Canada: Host ranges, feeding sites, and phenology of insects associated with European Rhamnaceae. Z. angew Ent. 65: 77-97.

Moran, R.C. 1981. Prairie fens in northeastern Illinois: floristic composition and disturbance. Stuckey, R.L.; Reese, K.J., eds. Proc. of the 6th North Amer. Prairie Conf. 278 p. (p. 164-168).

Nature Conservancy. London. Toxic chemicals and wildlife section. 1962-1963. Studies on the side effects of arboricides. Extracted from Report. p. 72-73. Taken from: Forestry Abstr. 25(2); 1964 (Abstract no. 2325).

Niehuss, M.H.; Roediger, K.J. 1974. Ammonium ethyl carbamoylphosphonate: A new plant growth regulator for the control of undesirable brush wood species. Proc. 12th Brit. Weed Control Conf., p. 1015-1022.

Packard, Steve. 1983. The Nature Conservancy, IL Field Office. Telephone conversation with C.K. Converse, The Nature Conservancy, Midwest Regional Office.

Parsons, Brian. 1983 Nov. 30. Naturalist, Holden Arboretum. Telephone conversation with C.K. Converse, The Nature Conservancy, Midwest Regional Office.

Pauly, Wayne. 1984 Jan. 3. Dane Co. Naturalist, Madison, WI. Telephone conversation with C.K. Converse, The Nature Conservancy, Midwest Regional Office.

Polunin, Oleg. 1969. Flowers of the World. London, England: Oxford University Press.

Raulo, J.; Leikola, M. 1975. (Studies on the annual height growth of trees.) (Finnish) Metsantutkimuslaitoksen Julkaisuja 81(2): 1-19. From English summary and chart (p. 10).

Reed, Donald. 1983 Dec. 12. Principle biologist, SE WI Regional Planning Commission. Telephone conversation with C.K. Converse, TNC, MRO.

Ridley, H.N. 1930. The Dispersal of Plants Throughout the World. Ashford, Kent, England: Reeve and Co.

Rohrig, E. 1953. (Successful trials of growth regulators for controlling weed growth in the forest.) (German) Forstarchiv 25(1): 5-9. Taken from: Forestry Abstr. 15(4): 459-460; 1954 (Abstract No. 3698).

Rosendahl, C.O. 1970. Trees and Shrubs of the Upper Midwest. Minneapolis, MN: Univ. Minnesota Press. 411 p.

Sannikov. G.P.; Tykvina, A.F. 1971. (Destroying undesirable woody vegetation by basal treatment with arboricides.) (Russian) Khimiya u Sel`skom Khozyaistve 9(12): 37-39. Taken from: Forestry Abstr. 35(4): 158; 1974 (Abstract No. 1564).

Soper, J.H.; Heimburger, M.C. 1982. Shrubs of Ontario. Toronto, Canada: Royal Ontario Museum.

Sukachev, V.N. 1928. Principles of classification of the spruce communities of European Russia. J. Ecology 16(1): 1-18.

Swink, F. 1974. Plants of the Chicago Region, 2nd ed. Lisle, IL: Morton Arboretum.

Tansley, A.G. 1968. Britian's Green Mantle: Past, Present, and Future. London, England: George Allen and Unwin. 327 p.

Trial, H. Jr.; Dimond, J.B. 1979. Emodin in buckthorn: a feeding deterrent to phytophagous insects. Can. Entomol. 111: 207-212.

Tyszkiewicz, S.; Dabrowska, J. 1953. (Stratification of the seeds of forest trees and shrubs.) (Polish) Roczn. Nauk. lesn 1: 155- 221. Taken from: Forestry Abstr. 15(4): 430; 1954 (Abstract No. 3466).

Vogl, R.J. 1969. One hundred and thirty years of plant succession in a southeastern Wisconsin lowland. Ecology 50(2): 248-255.

Ware, George. 1973. Research director, Morton Arboretum, Lisle, IL. Telephone conversation with C.K. Converse, TNC, MRO.

White, L. 1965. Shrub carrs of southeastern Wisconsin. Ecology 46(3): 286-304.

Wyman, D. 1971. Shrubs and Vines for American Gardens. New York: MacMillan Co.

Ziani, P. 1957. The amelioration by afforestation of strongly podzolized degraded sites of the continental oak region. (Croat.) Sum. List. 81(5/6): 169-205. Taken from: Forestry Abstr. 19(4): 530; 1958 (Abstract No. 4212).

Zimmerman, J.H. 1978. Notes on Wisconsin prairie fens - characteristics and relationships. Glenn-Lewin, D.C.; Landers, R.Q. Jr., eds., Proc. of Fifth Midwest Prairie Conf., Dept. Botany and Plant Pathology, Iowa State Univ., Ames, IA. 230 p. (p. 191).

IX. DOCUMENT PREPARATION & MAINTENANCE

Edition Date: 84-08-07

Contributing Author(s): Carmen K. Converse