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# Chapter

# 1

## Loranthaceae and Viscaceae in North America



### Mistletoes of Canada, Mexico, and the United States

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The mistletoes are a diverse group in the order Santales of shrubby, usually aerial, parasitic plants with fruits possessing a viscid layer (Kuijt 1968, 1969a). They are widely distributed geographically and as a group have a broad host range on conifers and other woody plants (Calder 1983). Many mistletoes are specially adapted for avian pollination and dispersal, and several avian species make extensive use of these resources (Kuijt 1969a, Watson 2001). The mistletoes are damaging pathogens of trees; and in many parts of the world are serious forest pests (Hawksworth 1983, Knutson 1983). General information on mistletoes is available at Calder and Berhhardt (1983), Cházaro and others (1992), Geils (2001a, 2001b), Gill and Hawksworth (1961), Kuijt (1969a), Mistletoe Center (2002), Nickrent (2002), Sinclair and others (1987), and Vega (1976).

The principal families of mistletoe are the Loranthaceae and Viscaceae (Calder 1983). The Eremolepidaceae, Misodendraceae, and several genera of Santalaceae could also be included as “mistletoes,” but these interesting parasites do not occur on North American conifers (Kuijt 1969a, 1988, Wiens and Barlow 1971). The loranthaceous and viscaceous mistletoes had been considered sub-families within the Loranthaceae but are now recognized as distinct, related families (Barlow 1964). There are several anatomical, embryological, and chromosomal differences between the two families (Kuijt 1969a, Wiens and Barlow 1971), but a practical difference is that the flowers in the Viscaceae are small and inconspicuous, whereas those in the Loranthaceae are large, colorful, and possess a calyculus (see Venkata 1963). The Viscaceae occur in tropical and temperate zones of the Northern Hemisphere; the Loranthaceae are generally tropical (Barlow 1983). The two families overlap in Mexico (Cházaro and Oliva 1987a, 1987b, 1988a).

The mistletoes of conifers in the New World are *Cladocolea*, *Struthanthus*, *Psittacanthus*, *Dendropemon* (Loranthaceae) plus *Arceuthobium*, *Phoradendron*, and *Viscum* (Viscaceae) (table 1-1). Scharpf and others (1997) review these genera and list the other mistletoes that infect conifers elsewhere. The most important genera to North American forestry are *Arceuthobium*, *Phoradendron*, and *Psittacanthus*. Field guides or keys for the identification of these mistletoes include: Bello (1984), Bello and Gutierrez (1985), Hawksworth and Scharpf (1981), Scharpf and Hawksworth (1993), Standley (1920), Tropical Agriculture Research and Training Center (1992), and Unger (1992).

The genus *Cladocolea* Tiegh. includes at least 23 little-studied mistletoes mostly of Central and Southern Mexico (Cházaro 1990, Kuijt 1975a). Plants are erect or vine-like shrubs (fig. 1-1); most species are parasites of oaks or other broadleaf trees. These mistletoes cause little damage to their hosts; their greatest importance is scientific, as rare species in a curious genus. The species reported to infect conifers (table 1-2) are:

- *Cladocolea cupulata* Kuijt [Journal Arnold Arboretum 56(3):285–286, 1975]
- *C. microphylla* (Kunth) Kuijt [Journal Arnold Arboretum 56(3):313–317, 1975]

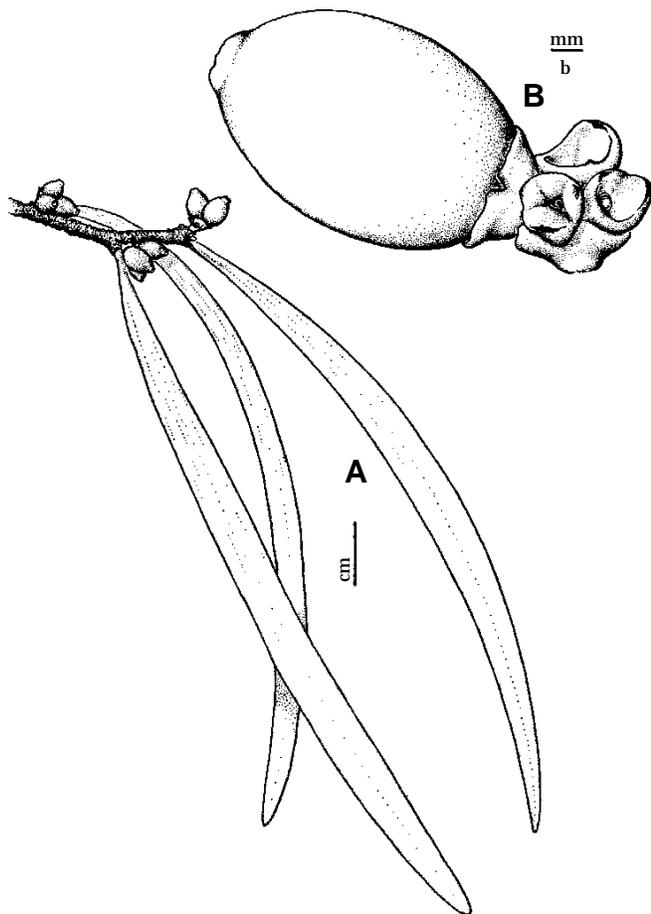
Mistletoes of the genus *Struthanthus* Mart. are climbing vines to several meters long (fig. 1-2). These mistletoes (“mata palo” or “tripa de pollo”) include 50 to 60 species from Mexico to Argentina (Bello 1984, Cházaro and Oliva 1988a, Kuijt 1964, 1975b). The *Struthanthus* mistletoes typically have broad host ranges that occasionally include a few conifers. The genus *Struthanthus* is a taxonomically chaotic and difficult group (Kuijt 1969a); applied names should be accepted with caution. The species reported to infect conifers (table 1-2) are:

- *Struthanthus deppeanus* (Schltdt. & Cham.) Blume [Systema Vegetabilium 7:1731, 1830]
- *S. interruptus* (Kunth) Blume [Systema Vegetabilium 7:1731, 1830]
- *S. palmeri* Kuijt [Canadian Journal Botany 53(3):252, 1975]
- *S. quericola* (Schltdl. & Cham.) Blume [Systema Vegetabilium 7:1731, 1830]

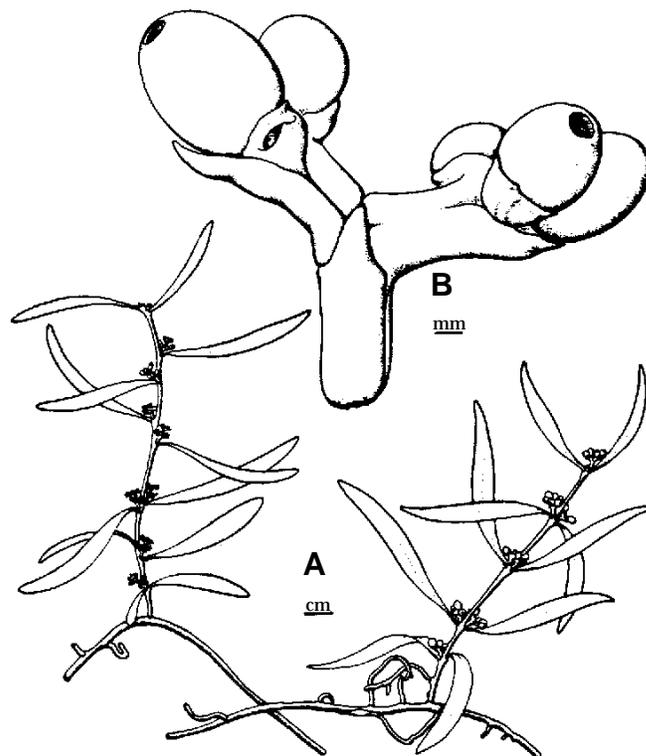
**Table 1-1**—Mistletoes of North American conifers.

Family	Genus	Distribution in North America	Conifer hosts in North America
Loranthaceae	<i>Cladocolea</i>	Mexico	<i>Pinus</i>
	<i>Struthanthus</i>	Mexico	<i>Pinus</i> , <i>Taxodium</i>
	<i>Psittacanthus</i>	Mexico	<i>Abies</i> , <i>Pinus</i>
Viscaceae	<i>Arceuthobium</i>	Canada, Mexico, United States	<i>Abies</i> , <i>Larix</i> , <i>Picea</i> , <i>Pinus</i> , <i>Pseudotsuga</i> , <i>Tsuga</i>
	<i>Phoradendron</i>	Mexico, United States	<i>Abies</i> , <i>Calocedrus</i> , <i>Cupressus</i> , <i>Juniperus</i> , <i>Taxodium</i>
	<i>Viscum</i>	Canada, United States	*

\*In North America, *Viscum* occurs as an introduced species only on angiosperms; elsewhere *Viscum* infects *Abies*, *Picea*, *Pinus*, *Pseudotsuga*, and *Juniperus*.



**Figure 1-1**—*Cladocolea cupulata*, **A** habit, pistillate plant and **B** fruit and supporting structure (three fruits removed). Illustration courtesy of Job Kuijt, edited from figure 9 in *Journal Arnold Arboretum*. 56(3): 285.



**Figure 1-2**—*Struthanthus palmeri*, **A** a habit, staminate plant and **B** fruit and supporting structure. Illustration courtesy of Job Kuijt, edited from figures 6 and 7 in *Canadian Journal of Botany* 53:252.

**Table 1-2**—*Cladocolea* and *Struthanthus* occurrence on conifers in Mexico.

Mistletoe	Distribution	Hosts	Reference
<i>Cladocolea cupulata</i>	Jalisco	<i>Pinus jaliscana</i> <i>P. lumholtzii</i>	Cházaro and others (1992)
<i>Cladocolea microphyllus</i>	Michoacán	<i>Pinus leiophylla</i> , <i>P. montezumae</i> , <i>P. pseudostrobus</i>	Bello Gonzalez (1984)
<i>Struthanthus deppeanus</i>	Chiapas, Oaxaca, Puebla, Veracruz	<i>Pinus patula</i>	Cházaro and Oliva (1988a)
<i>Struthanthus interruptus</i>	Michoacán	<i>Pinus lawsonii</i>	Bello Gonzalez (1984)
<i>Struthanthus palmeri</i>	Sonora	<i>Taxodium distichum</i> var. <i>mexicanum</i> <sup>c</sup>	Kuijt (1975b)
<i>Struthanthus quericola</i>		<i>Pinus</i> sp.	Cházaro and Oliva (1988a)

Note: These mistletoes are principally parasites of hardwoods over most of their distribution; this table presents only reports of the mistletoe on a conifer host and their joint distribution.

<sup>a</sup>Reported as *Struthanthus microphyllus*; determination by Kuijt (personal communication)

<sup>b</sup>Reported as *Struthanthus venetus*; determination by Kuijt (personal communication).

<sup>c</sup>Reported as *Taxodium mucronatum*.

*Struthanthus palmeri* (fig. 1-2) is found as far north as 60 km south of Nogales, AZ, and may be the most northern of the New World Loranthaceae (Kuijt 1975b). *Struthanthus* mistletoes cause little economic damage and are most important for scientific interest.

The genus *Psittacanthus* consists of 75 to 80 species, distributed from Mexico to Argentina on a wide range of angiosperm and gymnosperm hosts. In contrast to most of the other mistletoes of Mexico, the flowers are large and conspicuous—red, yellow, or orange (Cházaro and Oliva 1988a). Although about 10 species occur in Mexico, only four are parasites of fir or pine. These mistletoes are widely distributed but seriously damaging in only a few locations. The biology and management of these mistletoes are discussed in chapter 2.

The genus *Phoradendron* includes about 250 species, exclusive to the New World in tropical or temperate zones. Hosts include several genera of conifers, many broadleaf trees and shrubs, and other mistletoes. In some areas, *Phoradendron* mistletoes can be quite common and cause serious damage to conifers (Hawksworth and Scharpf 1981). The *Phoradendron* species on conifers are described in chapter 3.

The dwarf mistletoes, genus *Arceuthobium*, consist of 42 species of North and Central America, Europe, Asia, and Africa (Hawksworth and Wiens 1996). These mistletoes are restricted to conifers and usually quite damaging to their host. Descriptions, hosts, and distributions of 40 taxa are presented in chapter 4; damage, effects, and importance in chapter 5; survey methods in chapter 6; and management in chapters 7 and 8.

Two other genera of mistletoes are worthy of mention here. The European mistletoe, *Viscum album* L., was introduced to California by Luther Burbank about 1900 (Hawksworth and others 1991), and a recent introduction was discovered in 1988 for British Columbia (Muir 1989). Although subspecies of *Viscum album* are able to infect fir, spruce, pine, Douglas-fir,

and juniper native to North America, *Viscum album* in Canada and the United States is only reported on broadleaf trees (Barney and others 1998). This mistletoe is not considered a threat to natural conifer stands in North America. Two additional species of mistletoes on conifers have been collected from Hispaniola in the Caribbean (Kuijt, personal communication). *Dendropemon constantiae* Krug & Urban is an uncommon species usually found on *Pinus occidentalis*; and *D. pycnophyllys* Krug & Urban is a common species, apparently restricted to pine hosts.

Although many mistletoe genera share host species in common, there are only a few examples of two genera of mistletoe infecting the same tree (Hawksworth and Wiens 1996). *Abies concolor* is coinfectured by *Arceuthobium abietinum* and *Phoradendron pauciflorum* in California. *Pinus engelmannii* is coinfectured by *A. vaginatum* subsp. *vaginatum* and *Psittacanthus macrantherus* in Durango, Mexico. *Pinus pseudostrobus* is coinfectured by *A. globosum* subsp. *grandicaule* and *Psittacanthus macrantherus* in Michoacán, Mexico.

## Economic and Ecological Importance

Mistletoes have long been held by many peoples as special. Their sacred, mythical role in numerous cultures is documented by Frazer (1930) in his classic study of magic and the golden bough. Mistletoes are an inspiration for art (Becker and Schmoll 1986); their haustoria produce woodroses. In traditional, agricultural societies, mistletoes provide fodder, dyes, and drugs. Mistletoes are used for holiday decoration and models for new pharmaceuticals. A few North American mistletoes are narrow endemics threatened with extinction. Rolston (1994) describes the values of such species and why they ought to be preserved. Most mistletoes, however, have

## Key to Genera of Mistletoes in North America

1. Flowers with a calyculus, usually large and showy (Loranthaceae) ..... 2
  2. Flowers less than 1 cm long, light green; leaves less than 5 cm long and 2 cm wide ..... 3
    3. Inflorescence a determinate spike of monads ..... *Cladocolea*
    3. Inflorescence generally indeterminate, dioecious ..... *Struthanthus*
  2. Flowers 3–5 cm long, yellow or reddish; leaves 5–8 cm long and over 2 cm wide ..... *Psittacanthus*
1. Flowers without a calyculus, less than 3 mm long, same color as the shoots; plants leafless or with leaves less than 5 cm long or 2 cm wide (Viscaceae) ..... 4
  4. Fruit elongated and bicolored; seeds explosively dispersed (one exception); leafless; parasitic on pine, Douglas-fir, spruce, larch, fir, or hemlock ..... *Arceuthobium*
  4. Fruit round, uniformly colored pink, reddish, or white; seeds dispersed by birds; leafless or with well-developed leaves, parasitic on juniper, cypress, incense-cedar, bald-cypress or fir ..... *Phoradendron*

wide distributions, are locally abundant, and significantly alter the environment (Watson 2001). These mistletoes are important agents of disease, disturbance, and evolution. As pathogens, mistletoes affect host physiology (Knutson 1983, Kolb 2002). The results of tree disease are brooming, dieback, reduced growth, survival, and reproduction and increased susceptibility to other diseases and injuries. The consequences of an infestation are both economic and ecological. Mistletoes are forest pests for the commercial losses they cause and are influential symbionts for the many and complex interactions they affect. Assessing mistletoe importance revolves around two questions: how much (extent and abundance) and what effects.

Because mistletoes have major resources impacts (such as on timber yield), information is compiled regionally to describe their incidence and severity. North America consists of Canada, the continental United States of America, and the Republic of Mexico (fig. 1-3). North American mistletoes are found in most of the major coniferous forests and parasitize pine, fir, spruce, Douglas-fir, larch, hemlock, juniper, cypress, incense-cedar, and bald-cypress (table 1-1). The significant conifers not parasitized are arborvitae (*Thuja*), redwood (*Sequoia*), and giant sequoia (*Sequoiadendron*). The only mistletoes in Canada are dwarf mistletoes, but these occur across the country from Newfoundland to British Columbia. The most important are in eastern spruce bogs (Magasi 1984), central jack and lodgepole pine forests (Brandt and others 1998), and coastal hemlock forests (Alfaro 1985). Both *Phoradendron* and *Arceuthobium* occur in the United States. Although *Phoradendron* mistletoes are widely distributed across the Southern and Western States, the species that infect conifers are most common in the Western–Southwestern portion of the country (from western Texas to California, Colorado, and Oregon). *Phoradendron* mistletoes are abundant and damaging in some locations, but we know of no regional estimates of their incidence and severity. The dwarf mistletoes occur in the Northeastern States, Northern Lake States, Western States, and southeastern Alaska (see Forest Health Protection 2002). Drummond (1982) reports the infested area as 14 percent for the black spruce type in the Northern Lake States; 22 percent for the Rocky Mountain Douglas-fir type; 34 percent of the Rocky Mountain ponderosa pine type; 40 percent of the lodgepole pine type; and 22 percent of the commercial host type in Pacific states. Mistletoes including *Psittacanthus*, *Phoradendron*, and *Arceuthobium* are the principal cause of forest disease across Mexico. Mistletoes are most abundant in the cool or temperate coniferous forests and are found on more than 10 percent of the forest area (Hawksworth 1983). The forest area infected varies by State—Durango 15 percent, Nayarit 10 percent, Sonora

9 percent, Chihuahua 8.5 percent, Baja California 7 percent, Zacatecas 24 percent, Sinaloa 10 percent, and Jalisco 12 percent (Caballero 1968, 1970). Although the actual extent of infested area on a regional basis changes little from year to year, various definitions and data sources are used. These generate somewhat different estimates that are in broad agreement that mistletoes are common in some areas.

From an economic perspective, the effects of mistletoe infestation are described by Hawksworth (1993). Relevant to timber production, mistletoes reduce growth, yield, and quality and increase operation and protection costs for planning, harvesting, regeneration, and fuel management. Mistletoes are a concern in recreation areas for increased hazard from broom breakage (Hadfield 1999) and increased expense in vegetation management (Lightle and Hawksworth 1973).

From an ecological perspective, the effects of mistletoe infestations are complex because there are numerous criteria and relationships that might be considered relevant in a given situation. Allen and Hoekstra (1992) suggest describing ecological phenomena from alternative viewpoints or “criteria” of the population, species, community, landscape, and ecosystem. For a diseased tree, mistletoe infection means reduced competitive status and reproduction fitness (but see van Ommeren and Whitham 2002). The symbiotic relation between host and mistletoe has numerous population genetic and coevolutionary consequences that cannot be properly categorized as positive or negative (see Atsatt 1983, Norton and Carpenter 1998). Other species in addition to a host also are connected to the mistletoe by herbivory, pollination, use of the witches’ broom, or other relations. Watson (2001) recognizes mistletoes as keystone resources in many communities. Canopy effects are especially significant. Crown deformation and tree death affect composition of trees that compose the forest canopy and the structure of that canopy (Reid and others 1995). Numerous species, landscape, and ecosystem processes are consequently influenced—there are winners and losers, increases and decreases. Many indirect and long-term interactions involving mistletoes exhibit chaotic behaviors; a range of outcomes are likely rather than a single one determined (see Gleick 1988). The relevant fact is that mistletoes are often an important ecological and evolutionary agent driving that system (Holling 1992).

## Management Strategies

The mistletoe literature indicates not only that mistletoes have important effects but also that infestations can be affected by management intervention to change their spread and intensification. Effective



Figure 1-3—North America, Canada, United States of America, and Mexico with political subdivisions.

**Canadian Provinces, Territories and abbreviations**

Province-Territory	Abbreviation
Alberta	Alta.
British Columbia	B.C.
Manitoba	Man.
New Brunswick	N.B.
Newfoundland	Nfld
Northwest Territories	N.W.T.
Nova Scotia	N.S.
Ontario	Ont.
Prince Edward Island	P.E.I
Quebec	Que.
Saskatchewan	Sask.
Yukon Territory	Y.T.

**Mexican States and abbreviations**

Mexican state	Abbreviation
Aguascalientes	Ags.
Baja California	B.C.
Baja California Sur	B.C.S.
Colima	Col.
Coahuila	Coah.
Chiapas	Chis.
Distrito Federal	D.F.
Durango	Dgo.
Guerrero	Gro.
Guanajuato	Gto.
Hidalgo	Hgo.
Jalisco	Jal.
Michoacan	Mich.
Morelos	Mor.
México	Edo de Mex.
Nayarit	Nay.
Nuevo León	N.L.
Oaxaca	Oax.
Puebla	Pue.
Quintana Roo	Q. Roo
Querétaro	Qro.
Sinaloa	Sin.
San Luis Potosí	S.L.P.
Sonora	Son.
Tabasco	Tab.
Tlaxcala	Tlax.
Tamaulipas	Tamps.
Veracruz	Ver.
Yucatán	Yuc.
Zacatecas	Zac.

**U.S. states and abbreviations**

Province-Territory	Abbreviation
Alabama	AL
Alaska	AK
Arizona	AZ
Arkansas	AR
California	CA
Colorado	CO
Connecticut	CT
Delaware	DE
Dist. of Columbia	DC
Florida	FA
Georgia	GA
Idaho	ID
Illinois	IL
Indiana	IN
Iowa	IA
Kansas	KS
Kentucky	KY
Louisiana	LA
Maine	ME
Maryland	MD
Massachusetts	MA
Michigan	MI
Minnesota	MN
Mississippi	MS
Missouri	MO
Montana	MT
Nebraska	NE
Nevada	NV
New Hampshire	NH
New Mexico	NM
New Jersey	NJ
New York	NY
North Carolina	NC
North Dakota	ND
Ohio	OH
Pennsylvania	PA
Rhode Island	RI
South Carolina	SC
South Dakota	SD
Tennessee	TN
Texas	TX
Utah	UT
Vermont	VT
Virginia	VA
Washington	WA
West Virginia	WV
Wisconsin	WI
Wyoming	WY

intervention is both purposeful and persistent. Tkacz (1989) describes an approach called Integrated Resource Management used in the Southwestern Region, USDA Forest Service, that incorporates forest insect and disease considerations into a planning, implementing, and monitoring process. Many other organizations have comparable management systems. Common elements of these systems include (1) formulation of objectives, (2) review of the expected performance of alternatives, (3) selection and implementation, and (4) monitoring and reaction. Holling and Meffe (1996) warn of the dangers from attempting rigid control in natural resource management; they advocate an adaptive process for complex environments with changing objectives and management options. Although management in mistletoe-infested stands has not always been successful for various reasons (Conklin 2000), management processes and techniques are available with the potential for producing desirable results.

A simplistic review of one management strategy that once dominated conifer forestry is instructive. A prevailing objective on public forests in the 20<sup>th</sup> century was sustained economic production of timber. Foresters knew that dwarf mistletoes were obligate parasites that died when the host tree was cut and had limited capability of spread (Weir 1916b). The preferred control technique was clearcutting in large blocks to remove the mistletoe and retard reinfestation (Stewart 1978). Where employed, it worked. A challenge to forest pathologists arose when objectives were expanded to include wildlife and aesthetic values, and treatments required or produced infrequent, selective removal that left infected trees. At least in the American Southwest, dwarf mistletoe infestations were not fading away (Conklin 2000, Maffei and Beatty 1988). Other control techniques based on biological, chemical, genetic, and silvicultural approaches were needed (Scharpf and Parmeter 1978, Muir 1993).

Hawksworth (1978) and Parmeter (1978) describe the epidemiological bases for control of dwarf mistletoes that can be extended with modification to other mistletoes. For technical and management reasons, silvicultural approaches have been used more com-

monly than chemical or biological control or genetic selection. Although there has been some success with chemical controls, phytotoxicity and need for reapplication have limited this approach (Adams and others 1993, Lichter and others 1991, Scharpf 1972). The concepts of control with biological agents are well developed (DeBach 1964), and use of insects and fungi on mistletoes has been considered (Cházaro and others 1992, Julian 1982, Mushtaque and Balock 1979). There is evidence for inherited variation in host resistance to infection by at least the dwarf mistletoes. Genetic selection may provide regeneration alternatives (Ringnes and others 1996). Silvicultural approaches include pruning, sanitation, species replacement, and other techniques that rely on cutting trees. As with chemical, biological, and genetic approaches, cultural methods must be adapted to fit the mistletoe and host combination in the context of specific management objectives and constraints.

Assessment and monitoring are essential elements of a strategy for managing mistletoes. Mistletoe infestations initially develop slowly but accelerate rapidly and cause significant departure from typical stand development. These facts suggest that early intervention provides greater flexibility and that a good model of stand response is useful for predicting what a treatment might produce in 20 to 40 years. Although the Dwarf Mistletoe Impact Model (Forest Health Technology Enterprise Team 2002) is primarily intended for assessing silvicultural alternatives, it (and other models) can be modified or developed for evaluating tactics of deploying biological agents or genetically selected stock (Robinson and others 2002).

The mistletoes of North American conifers range from obscure species in remote locations to major forest pests. Management varies from intensive timber production to biological conservation. Although these mistletoes can have significant impacts on forest conditions, they are also subject to management influence through various methods that alter rates of spread and intensification. Knowing which methods are appropriate and effective requires an understanding for each kind of mistletoe: its life history, hosts, distribution, effects, and ecology.