

# PACIFIC YEW: A FACULTATIVE RIPARIAN CONIFER WITH AN UNCERTAIN FUTURE<sup>1</sup>

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*Abstract: Increasing demands for Pacific yew bark, a source of an anticancer agent, have generated interest in defining the yew resource and in exploring strategies to conserve this species. The distribution, riparian requirements and ecosystem functions of yew populations in coastal and inland forests of northern California are outlined and alternative approaches to conserving this resource are identified. Efforts to obtain additional information on genetic diversity of yew populations and to insure careful management of the species are essential for the protection of this resource.*

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Yews represent a genetic resource at risk. At least three species—the English yew (*T. baccata*), Florida yew (*Taxus floridana*), and Pacific yew (*T. brevifolia*)—have evolved a unique assemblage of characteristics that confer upon these trees and shrubs unprecedented vulnerability. The English yew, native to Europe, north Africa and parts of the Middle East, was valued for centuries as a strategic resource. The Florida yew, restricted to bluffs and ravines on the eastern bank of the Apalachicola River in northern Florida (Sargent 1961), is classified as a rare and endangered conifer (Barnes 1983). Now the survival of Pacific yew populations in western states may be threatened by the discovery that yew bark is an important source of an antitumor drug.

The yew has the longest tradition as a protected tree. In the 15th century, English yew populations were severely depleted; their fine-grained elastic wood was valued for archery bows. Laws mandating protection of this species date from 1423, (Szafer, W. 1965, cited in Bialobok, 1975). In many parts of central Europe and the Transcaucasus, the English yew remains a rare and vanishing conifer (Karczmarszuk 1986; Safarov 1986).

New demands for the yew have recently emerged. Although it has not been listed as an endangered species, environmentalists have expressed concern that populations of Pacific yew in California and other Western states may also suffer depletion (Booth 1987). Yew bark is currently the chief source of taxol—a diterpenoid antitumor agent (Suffness; Douros 1979; Wani and others 1971). The National Cancer Institute in cooperation with the USDA Forest Service have contracted for the

selective harvesting of the Pacific yew in California, Oregon and Washington. In 1988, 60,000 pounds of bark were harvested from 12,000 trees in western Oregon; another harvest of the same magnitude is scheduled for 1989 (C. Bolsinger, personal communication).

This paper briefly outlines the current status of the Pacific yew as a facultative component of riparian forest communities in northern California and other Western states, and addresses questions that bear on possible strategies to conserve the yew resource without intervening with ongoing cancer research.

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## Pacific Yew as a Riparian Resource

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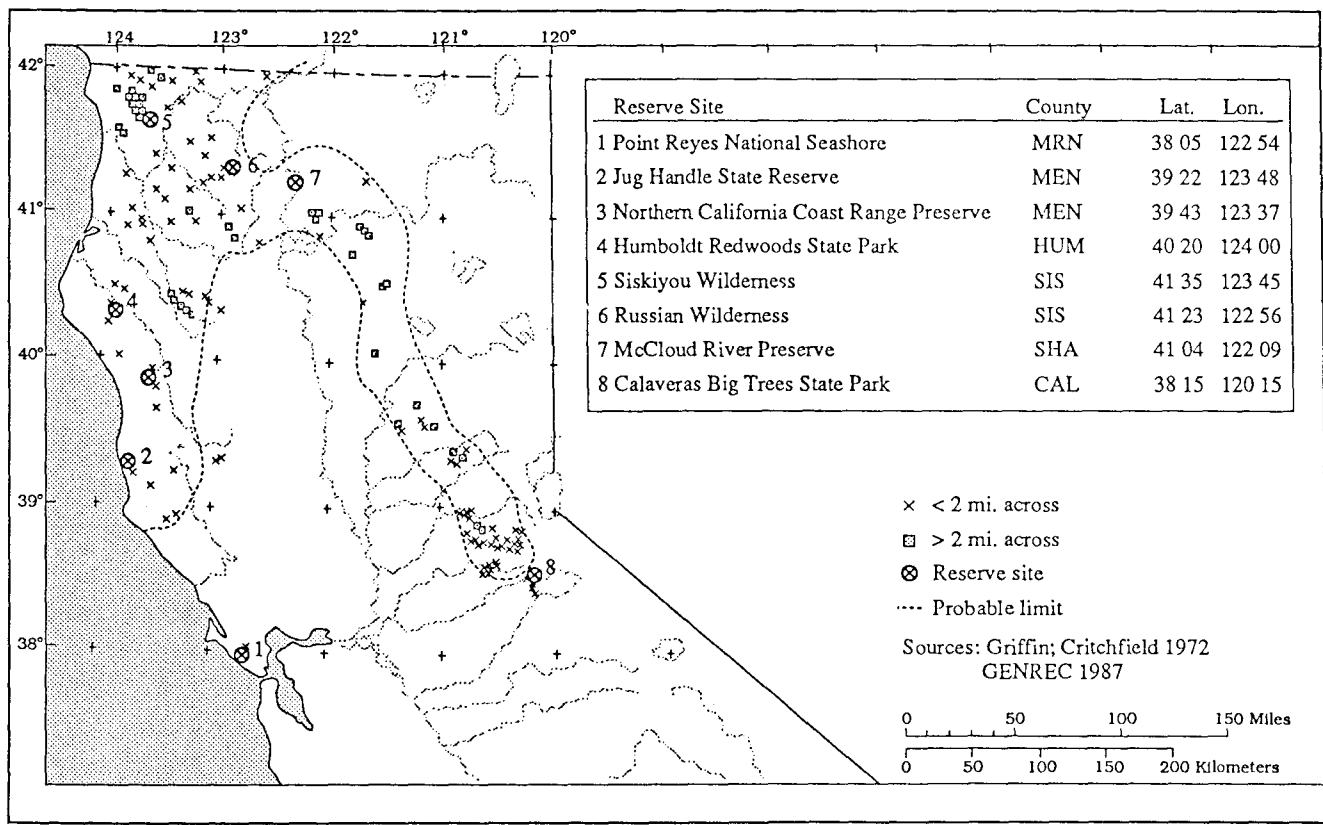
In the Coast Range, on the inland forests of the Klamath and Cascade ranges, and the northern Sierra Nevada of California, the Pacific yew grows as scattered individuals and small groups of trees on or near stream banks and river margins, canyon bottoms and wet shaded ravines, and other moist habitats (Crawford and Johnson 1985; Griffin and Critchfield 1972; Jimerson 1988). Forest inventory data show that this tree is distributed from 100m in the coastal redwood to 1300m in the mixed conifer forests of the central and northern Sierra Nevada. At higher elevations, the Pacific yew may occupy less moist sites on north and east slopes. In the northern part of its range, this facultative riparian species utilizes a variety of moist habitats; however, as it approaches the southern limit of its range, the yew population tends to be more restricted and more obligate in meeting its riparian requirements (Jimerson 1988; F. Johnson, personal communication).

Yews are slow-growing, long-lived, and shade tolerant (Minore 1979). In northwestern California, they form an understory layer in association with coast redwood, Douglas-fir, tanoak, bigleaf maple, vine maple, other hardwoods, and conifers (Jimerson 1988). The dense yew subcanopy provides shading; thus, it contributes to maintaining temperature control along tributaries of small streams for juvenile salmon and steelhead (Jimerson 1988). Yews provide cover and serve as an important food source for browsing deer and other ungulates (Pierce 1984; Pierce and Peek 1984). Several

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**Figure 1** – Distribution of Pacific Yew (*Taxes brevifolia* Nutt.) and location of designated reserve sites containing *T. brevifolia* in northern California.

groups of birds—thrushes, blackbirds, waxwings and nuthatches—are reported to feed on the fleshy aril and help to disseminate seeds of the yew (Bartkowiak 1975; Sudworth 1967).

## The Need for Further Studies

Until recently, the Pacific yew was not considered commercially important; accordingly, virtually no information is available on yew population structure, or how yew trees produce taxol. Many questions need to be addressed, such as: How does the annual growth rate compare with the cutting (harvesting) rate? Studies are needed to provide baseline data on the amount and patterns of genetic variation in the species. Three cultivars of Pacific yew have been reported—*Erecta*, *Nana* and *Nuttallii* (Taylor and Taylor 1982). The extensive range of this species—from northern California to southern Alaska—suggests that geographic races have evolved. A range-wide study of isozymes and other measures of

biodiversity would provide additional data on genetic variation. This information is essential for silvicultural management, for studies of variation in taxol, and for conservation of the species.

## Conserving the Resource

Gene resources can be preserved *in situ*—in reserves, or *ex situ*—in seed banks or arboreta (Ledig 1986). Five major natural reserve programs have been established in California. Among the most ambitious are the University of California Natural Reserve System and the USDA Forest Service Research Natural Area program (Ford and Norris 1988). Although Pacific yew is not identified as a target element in established reserves, several contain significant populations of this species (GENREC 1987; Hood 1975-1980) (fig. 1).

In outlining the scope of gene conservation for forest trees, Ledig (1988) has underscored the need to establish larger areas—genetic resource management units

(GRMUs)—to protect coevolved gene complexes. He argues that existing reserves are inadequate; their small size increases the probability of extinction. GRMUs differ from strict reserves; logging can continue, but other forms of management promote genetic conservation. Ledig urges conservationists to evaluate existing reserve natural areas and persuade Federal and State land management agencies to establish GRMUs to fill the gaps. Yew populations need to be preserved in GRMUs now, to assure their future availability.

Identifying alternative strategies for producing taxol represents another approach to conserving the Pacific yew. Several methods are being considered: *in vitro* cell and tissue culture; stimulation of biosynthesis through precursor feeding; and isolation of genes for cloning and expression of taxol. Evidence for cell culture of Pacific yew has only recently been reported from two laboratories (Blume 1989). To date, none of the immediate precursors of taxol have been identified. We know of no studies on the isolation of genes controlling taxol biosynthesis and their expression.

Future use of forest genetic resources will be determined by current management strategies and practices. Failure to respond to this challenge could significantly reduce or eliminate the genetic diversity upon which natural selection acts (California Gene Resources Program 1982). One of the victims of that neglect could be the Pacific yew.

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## Summary and Recommendations

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The current status of the Pacific yew (*Taxus brevifolia* Nutt.) as a facultative riparian component of the subcanopy in mixed conifer forests of northern California and other Western States was briefly outlined. Current demands for yew bark as a source of taxol—a diterpenoid antitumor agent—call attention to the need for additional information on this valuable resource. If clinical research trials with taxol are successful, then pressures to increase the harvesting rate of Pacific yew can be expected. Developing *in vitro* technologies for producing taxol represents one approach to conserving Pacific yew populations. In addition, range-wide studies of the genetic architecture are essential to provide baseline data for silvicultural management, for variation in taxol, and for conservation of the species. Efforts to identify and preserve a diversity of yew alleles and co-evolved gene complexes must be expanded. Clearly, Pacific yew is in a transitional phase between non-commercial status and commercial exploitation. Careful management of this species will be required to protect this valuable resource.

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## Conclusions

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The discovery of taxol in yew bark poses a threat to yew populations and a challenge for humankind. We should expect to face such realities in the future as we identify and utilize genetic resources of other plant species. Strategies to both protect and manage the yew resource must be developed quickly if we are to preserve this valuable riparian species.

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## References

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- Barnes, Lee. 1983. Micropropagation of endangered native conifers, *Torreya taxifolia* and *Taxus floridana*. Hortscience 18(4): 617.
- Bartkowiak, Stanislaw. 1975. Seed dispersal by birds. In: The Yew, *Taxus baccata* L.S. Bialobok, ed. Available from NTIS. Springfield VA.; 139-146
- Bialobok, Stefan, *ibid.*
- Blume, E. 1989. Investigators seek to increase taxol supply. Journal of the National Cancer Institute 8(15): 1122-1123.
- Booth, William. 1987. Combing the Earth for cures to cancer, AIDS. Science 237(4814):969-970.
- California Gene Resources Program. 1982. Douglas-fir genetic resources. An assessment and plan for California. Berkeley, CA: National Council on Gene Resources; 275p.
- Crawford, Rex C.; Johnson, Frederic D. 1985. Pacific yew dominance in tall forests, a classification dilemma. Canadian Journal of Botany 63(3): 592-602.
- Ford, Lawrence D.; Norris, Kenneth S. 1988. The University of California natural reserve system. Bioscience 38(7): 463-470.
- Genetic Resource Consultants (GENREC). 1987. The California forest genetic sources [FGS] catalog. Version 1.0. User manual. Berkeley, CA: Genetic Resources Consultants; 20 p.
- Griffin, James R.; Critchfield, William B. 1972. Distribution of forest trees in California. Res. Paper PSW-82. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 114 p.

- Hood, Leslie. ed. 1975-1980. Inventory of California natural areas. Sonoma, CA: California Natural Area Coordinating Council; 12 volumes.
- Jimerson, Thomas M. 1988. Ecological types of the Gasquet Ranger District, Six Rivers National Forest. Forest Service, U.S. Department of Agriculture; 164 p. Unpublished draft supplied by author.
- Karczmarczuk, R. 1986. English yew *Taxus baccata*, its history, present status, and its future. Kosmos. Series A. Biology (Warsaw) 35(2): 285-292.
- Ledig, F. Thomas. 1986. Conservation strategies for forest gene resources. Forest Ecology and Management 14(1): 77-90.
- Ledig, F. Thomas. 1988. Conservation of diversity in forest trees. BioScience 38(7): 471-479.
- Minore, Don. 1979. Comparative autecological characteristics of northwestern tree species—a literature review. Gen. Tech. Rep. PNW-87. Portland, OR: Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 72 p.
- Pierce, D. John. 1984. Siras moose forage selection in relation to browse availability in north-central Idaho. Canadian Journal of Zoology 62(12): 2404-2409.
- Pierce, D. John.; Peek, James D. 1984. Moose habitat use and selection patterns in north-central Idaho. Journal of Wildlife Management 48(4): 1335-1343.
- Safarov, I.S. 1986. Rare and vanishing species of the eastern transcaucasian dendroflora and their protection. Botanicheskii Zhurnal (Leningrad) 71(1): 102-107.
- Sargent, Charles S. 1961. Manual of trees of North America 1: 94-95. New York: Dover Publ. Co.
- Sudworth, George B. 1967. Forest trees of the Pacific slope. New York: Dover Publ. Co.; 455 p.
- Suffness, Matthew; Douros, John. 1979. Drugs of plant origin. Methods of Cancer Research 16: 73-126.
- Taylor, Roy L.; Taylor, Sylvia. 1981. *Taxus brevifolia* in British Columbia. Davidsonia 12(4): 89-94.
- Wani, M.C.; Taylor, L.H.; Wall, M.E. 1971. Plant antitumor agents. VI. The isolation and structure of taxol, a novel antileukemic and antitumor agent from *Taxus brevifolia*. Journal of the American Chemical Society 93(9): 2325-2327.