Native Fern Propagation in Glacier National Park's Native Plant Nursery

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Avalanche Creek in Glacier National Park

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Abstract

Six species of native ferns have been propagated by spores and rhizome division in Glacier National Park's Native Plant Nursery. Beginning with spores, plants are ready for the field in 14 to 16 mo. Rhizome division is used for further increase of nursery stock. The life cycle of ferns is also discussed.

KEYWORDS: *Adiantum*, *Athyrium*, *Dryopteris*, *Gymnocarpium*, spore propagation

NOMENCLATURE: Flora of North America (1993)

Twenty-two species of ferns grow in Glacier National Park (Lesica 1996) in a diverse range of habitats including seeping alpine cliff faces, xeric-like talus slides and boulder fields, moist wooded slopes, stream banks, and forests. Ferns are a prevalent component of the understory in a mature *Thuja plicata*/*Oplopanax horridum* habitat type (Pfister and others 1977) in the Avalanche Creek drainage of Glacier National Park. Proposed restoration efforts in this drainage prompted Park staff to investigate fern propagation techniques. Ferns can be sexually propagated by spores or asexually propagated by division. In Glacier National Park's Native Plant Nursery, 6 species representing 4 genera in 2 fern families have been successfully propagated by spores and division.

Propagation by Spores

An understanding of the life cycle of ferns is essential for successful fern propagation in nurseries. Ferns have 2 life stages: the gametophyte and the sporophyte, the latter being the spore producing fern plant we are all familiar with (Figure 1). Sporangia are variously placed on the lower surface of leaves and grow in clusters known as sori. In many species, the sori are covered by specialized outgrowths of the leaf, the indusia, which lift and shrivel when spores are ripe. A specialized layer of cells (the annulus) on the stalks of spores contracts and expands, disseminating mature spores with a catapult-like discharge (Figure 2).

Disseminated spores germinate upon contact with a suitably moist substrate. Spore germination results in the gametophyte (Figure 2),

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Taxonomy and Distribution of Species Grown at Glacier National Park

Taxonomy of ferns in North America has been extensively revised. The formerly recognized fern family Polypodiaceae is now divided into 16 families. Fern nomenclature, distinguishing morphological characters, and geographic distribution of species propagated at Glacier National Park are described below.

Pteridaceae Reichenbach

Western maidenhair fern (*Adiantum aleuticum* (Ruprecht) Paris)

Formerly, the western maidenhair fern was treated as a variant of *Adiantum pedatum* L., but both species are reproductively isolated from each other and differ in several morphological characters (Paris and Windham 1988). Apices of leaf margins in *A. pedatum* L. have rounded, crenulate, or crenate-denticulate lobes (0.1 to 2 mm long) that are shallowly separated. Segments at the middle of the divisions of blades are usually less than 3.2 times as long as broad. Apices of the leaf margins in *A. aleuticum* have sharply denticulate, angular lobes, and the lobes are separated by deep sinuses, 4 to 6 mm long. Segments at the middle of the divisions of blades are usually more than 3.2 times as long as broad. Therefore, *A. aleuticum* is now recognized as a distinct species growing in a variety of habitats throughout its range, from sea level coastal cliffs, through moist wooded ravines and forests, to subalpine boulder fields, up to 3200 m (10,500 ft) elevation. It ranges from Newfoundland, Quebec, British Columbia and Alberta, all of the US west of the Rocky Mountains, Maine, Maryland, Pennsylvania, Vermont, and in the state of Chihuahua, Mexico. This species is disjunct in wet rock fissures at high elevations in the Intermountain and Rocky Mountain states and in Mexico.

Dryopteridaceae Herter

American alpine lady fern (*Athyrium alpestre* (Hoppe) Clairville var. *americanum*)

Athyrium alpestre var. *americanum* differs from *A. alpestre* var. *distentifolium* L. of Europe in several morphological characters. The leaves of *americanum* are more finely dissected and pinnae are broader with larger basal pinnules than *distentifolium*. Indusia are absent or very rudimentary in the American variety. *Athyrium alpestre* var. *americanum* grows from 600 to 3100 m (1970 to 10,170 ft) elevation, on wet talus slides, rocky slopes and alpine and subalpine meadows. It is native in all the Canadian provinces from Quebec westward, Alaska, and south through California, Nevada, Oregon, Washington, Idaho, Montana, Wyoming, Utah, Colorado, and South Dakota.

Northwestern lady fern (*Athyrium filix-femina* (L.) Mertens var. *cyclosorum*)

Athyrium filix-femina is a circumboreal species with 4 recognized North American varieties. The variety *cyclosorum* is distinguished from the other 3 varieties by having pinnules that are deltate to oblanceolate, being nearly equilateral at the base. It grows in moist woods, swamps, and stream banks from 10 to 1600 m (33 to 5250 ft) elevation, from Quebec westward across Canada, Alaska, south to Washington, Oregon, California, Montana, Idaho, and South Dakota.

Toothed wood fern (*Dryopteris carthusiana* (Villers) H.P. Fuchs Bull.)

Dryopteris carthusiana is a circumboreal species that grows in swampy woods, moist wooded slopes, stream banks, from sea level to 1200 m (3940 ft) elevation. It occurs in North America across Canada, the northeastern and upper midwestern states, and in Washington, Idaho, and northwestern Montana.

Male fern (*Dryopteris filix-mas* (L.) Schott, Gen. Fil.)

Dryopteris filix-mas grows in moist woods, stream banks, and among boulder and talus of igneous rock in the Rocky Mountains, from 200 to 2500 m (655 to 8200 ft) elevation. It is a circumboreal species that is native in North America throughout the western states and across Canada to Greenland, the upper Great Lakes region, and the northeastern US.

Common oak fern (*Gymnocarpium dryopteris* (L.) Newman)

Gymnocarpium dryopteris is a fertile allotetraploid species that arose following hybridization of *G. appalachianum* and *G. disjunctum* (Pryer and Huafler 1993). Its wide distribution across North America has allowed for secondary contact with both diploid parents, resulting in sterile triploid plants that produce 2 types of spores: 1) malformed spores incapable of germination, and 2) round, viable spores which germinate and plants can arise apogamously (Pryer and Britton 1983). Collection of spores from triploid populations requires careful discernment between non-viable and viable spores. *Gymnocarpium dryopteris* is a circumboreal species that grows from Alaska across Canada to Greenland, and south to Washington, Oregon, Idaho, Montana, Wyoming, South Dakota, Colorado, New Mexico, and the upper Great Lakes and northeastern states. It grows in coniferous forests, stream banks, and moist cliffs from sea level to 3000 m (9840 ft) elevation.

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Figure 1 • Indusia and mature spores on the underside of a frond of Dryopteris filix-mas.

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which begins development as a small, pale green, algae-like chain of cells known as the germ filament. Development continues into a flat, heart-shaped structure called the prothallus (Figure 2). Slender holdfasts, known as rhizoids, develop on the lower surface of the prothallus. Both reproductive structures, the antheridium (male), and the archegonium (female), develop on the lower surface of the prothallus. Antheridia usually appear before the archegonia, mostly near the rhizoids. Archegonia appear near the notch of the prothallus. Water must be present for the multiflagellate sperm to swim from an antheridium to eggs in the archegonium. After fertilization, the young sporophyte receives its nutrients from the gametophyte through a foot-like structure. Further development is rapid, and once the sporophyte achieves a level of photosynthesis sufficient to maintain itself, the gametophyte disintegrates (Figure 2). The sporophyte completes the life cycle when it grows into a mature fern plant and produces spores.

Spore Collection and Processing

Field plants should be located in early summer and inspected for the presence of sporangia on the under surface of leaves. Spore maturation, much like seed maturation, is variable depending on weather conditions throughout the growing season. In Glacier National Park at 1050 m (3450 ft) elevation, sporangia reached maturity in mid to late August. Sporangia must be monitored with a hand lens on a regular basis. The entire frond is collected when indusia (if present) begin to lift and spores appear fully mature and are the ripe color for that species (Table 1; Figure 1).

Fronds are placed spore-bearing surface down on butcher paper or newspaper and are kept indoors under warm and dry conditions (20

TABLE 1

Indusia characteristics and mature spore color

Species	*Indusia*	*Mature spore color*
Adiantum aleuticum	false indusia	tan
Athyrium alpestre	none	tan
Athyrium filix-femina	flaplike, thin, translucent	tan
Dryopteris carthusiana	horseshoe or kidney shaped	black
Dryopteris filix-mas	horseshoe or kidney shaped	black
Gymnocarpium dryopteris	none	dark brown to black

to 25 °C [68 to 77 °F]) without air movement for 7 to 10 d. Spores will appear as a fine dust on the paper and can be immediately sown or stored in sealed containers for future use. Under ideal storage conditions at 0 °C (32 °F) and 10% humidity in airtight sealed containers, spores can remain viable for up to 5 y (Foster 1984).

Spore Germination

Germinate spores using sterilized propagation flats with drainage holes. Any sterilized commercial soilless growing mix composed of 6:1:1 milled sphagnum peat moss:perlite:vermiculite is an appropriate medium. Moisten the medium thoroughly with distilled water. Hand sow spores directly on the surface of the moist medium evenly and seal with clear plastic to maintain humidity and avoid fungal contamination. Flats should be placed under soft incandescent lights (60 watts) on a timer for 12 h photoperiod at room temperature (20 to 23 °C [68 to 73 °F]). Periodic watering of the flats using a spray bottle containing distilled water will be necessary. Water should be applied when the medium begins to dry slightly on the surface. Flats should also be closely monitored for any fungal contamination.

Spores germinate 10 to 20 d after sowing. The thread-like germ filament can be seen with the aid of a microscope. Generally, prothalli become visible 20 d after sowing. Prothalli continue to grow for up to 10 wk before reproductive structures, antheridia and archegonia, become evident on the under surface of the prothallus. Both structures can be seen with a microscope when sampling a few prothalli from a tray. Once reproductive structures appear, it is important to maintain a thin film of water over the surface of the prothalli; heavy misting using distilled water should be applied to the sealed flats once or twice a day. This is necessary for fertilization to occur. However, unfertilized prothalli can continue to live for years until the correct moisture conditions exist for fertilization. The clear plastic is removed from the tops of the flats when antheridia have withered and disappeared, usually 4 wk after their initial appearance. Flats are then transferred from under indoor lights to the greenhouse.

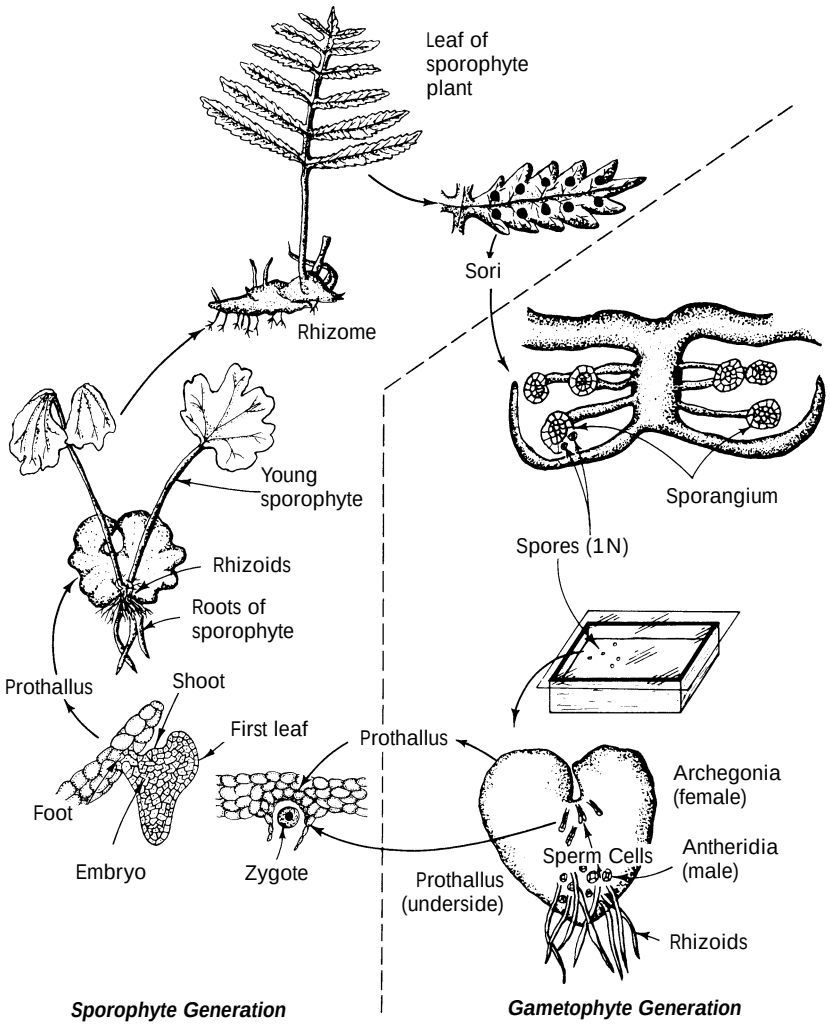

Figure 2 • Development of spores in the reproduction cycle of a fern. (Source: Hartmann and others (1997). Reprinted by permission of Prentice-Hall Inc, Upper Saddle River, New Jersey.

Growth and Development of Plants

Young fern plants (sporophytes) with true leaves and a developing root system appear approximately 5 mo after sowing the spores. Individual plants that are 4 cm (1.5 in) tall with at least 2 true leaves are transplanted into 590- or 800-ml (36- or 49-in^3) containers using Pro-Mix #1 medium (3:1 peat moss:perlite). Osmocote controlled release fertilizer (13N:13P_2O_5:13K_2O; 8 to 9 mo release rate at 21 °C [70 °F]) and Micromax fertilizer (12% S, 0.1% B, 0.5% Cu, 12% Fe, 2.5% Mn, 0.05% Mo, 1% Zn) are added at a rate of 4 g and 2 g per 800-ml container, respectively (5 and 2.5 kg/m^3 [8.4 and 4.2 lb/yd^3]). Continued growth occurs rapidly under greenhouse conditions and plants can be moved to an outdoor shadehouse or a shaded location after the last frost in spring. All 6 species are rhizomatous and roots form a firm root plug in the containers by the end of the growing season. Plants can be fall planted in early September. If they are to be held over, plants must be potted up

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TABLE 2

General propagation timeline of native ferns in Glacier National Park

	Athyrium alpestre ***Athyrium filix-femina*** ***Dryopteris carthusiana*** ***Dryopteris filix-mas*** ***Gymnocarpium dryopteris***	***Adiantum aleuticum***
Collect spores	Aug 20 to 28	Aug 25
Sow spores in propagation trays	Aug 28 to Sep 1	Sep 15
Gametophytes appear in trays	Sep 15 to 20	Nov 15
Appearance of reproductive structures and fertilization	Dec 1	Jan
Sporophytes appear	Jan 20 to Feb 20	Feb
Transplant into 800-ml pots	Mar	Late Mar
Continued growth in outdoor shadehouse	May 25 to Oct 25	May 25 to Oct 25
Root tight—outplant if desired	Sep 1	Sep 1
Overwinter in outdoor shadehouse	Oct 25 to May 1	Oct 25 to May 1
Transplant overwintered stock into 3-l containers	May 15 to Jun 1	May 15 to Jun 1

the following spring into 3-l (1-gal) containers. Plants reach reproductive maturity 2 y after initial spore germination. Although it takes 1 y to reach sizable nursery stock, literally thousands of plants can be produced from a few propagation trays.

Vegetative Propagation

Because all 6 species are rhizomatous, they can be increased from established nursery stock by division. *Adiantum*, *Athyrium*, and *Dryopteris* have rhizomes that are relatively thick and shortened in relation to length. Individual sections of the rhizome with 1 non-dormant lateral bud are made using a sharp knife, one-third of the fronds are removed, and the individual sections are transplanted into containers. *Gymnocarpium* has very slender rhizomes with long internodes. These rhizomes are divided essentially the same way as the other species; ensuring that each section has at least 1 non-dormant lateral bud. Divisions are done in the spring prior to or just after the appearance of the tightly coiled fronds (fiddleheads).

Rhizome wounding has been done on *Athyrium alpestre* and *Athyrium filix-femina*. Rhizomes were split down the center axis with a sharp knife, cut into 20-cm (8-in) lengths, and planted 3 to 4 cm (1.5 in) deep in a raised outdoor bed containing a coarse growing medium (2:2:1:1 peat moss:sand:perlite:vermiculite). Individual plants grow from the split rhizomes the following year.

Summary

Using spores, ferns can be grown in the greenhouse and outdoor nursery and out planted on appropriate sites in 14 to 16 mo. The basic steps in propagation include: 1) monitoring spore maturity in the field; 2) collecting fronds with mature, viable spores; 3) germinating spores on moist media; 4) growing gametophytes and providing conditions for fertilization; 5) growing sporophytes to necessary size for outplanting; 6) increasing nursery stock by rhizome division the following year, if needed. This protocol has been successful for 4 genera.

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