Introduction

Seed is essential in the regeneration of forests. It is the primary method used by conifers to reproduce, maintain genetic variability, and become established on appropriate sites. Currently in B.C., between 3000 and 4000 kilograms of seed are used annually to produce over 200 million seedlings (Figure 1). An average of 15 kilograms of seed is required to produce one million seedlings. This quantity varies greatly by **species**[1] from 5 kg for western redcedar[2] to 220 kg for Amabilis fir.[3]

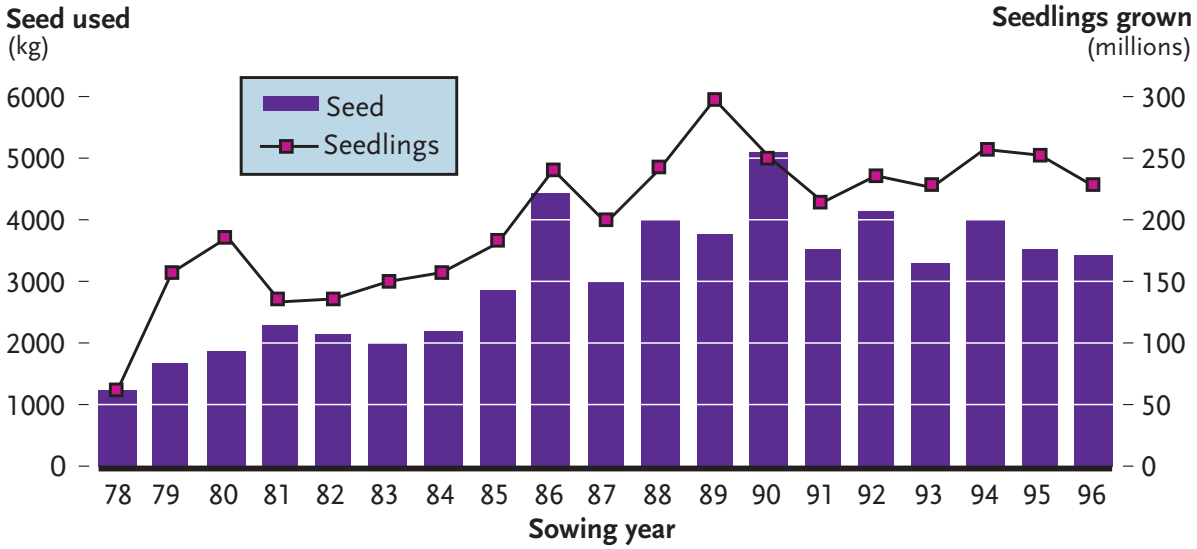

Figure 1

Kilograms of tree seed used and number of seedlings grown in British Columbia 1978–1996.

This volume focuses on the **anatomy** and **morphology** of healthy, viable, mature, cleaned **conifer** tree seed. Seed characteristics will be explored from the dry seed in storage, through **imbibition** and **stratification** to radicle emergence and **seed coat** shedding. For simplicity, the term 'dry' is used throughout this volume to refer to seed at the preferred **moisture content** for long-term storage (4.9–9.9%) and 'imbibed' used to refer to seed that have fully saturated internal components. Examples of immature, damaged, and diseased seed are also presented to allow readers to identify and quantify through cutting tests some of the problems that can be found with tree seed. Emphasis is placed on those characteristics having operational significance.

1 Words in bold are defined in Appendix 2.
2 Scientific names are listed in Appendix I; common names are used throughout the text.
3 Based on PSB 415B styroblocks.

The objectives of this volume are to:

- **consolidate available information and provide a highly pictorial reference to familiarize the reader with conifer tree seed anatomy and morphology**
- **encourage the use of cutting tests to evaluate seed quality.**

Seed from Cones

In conifers, male cones produce pollen and female cones produce **ovules**. Seed are produced through the fertilization of an ovule by a pollen grain. In most conifers, both types of cones occur on the same tree. The female cones, which contain the seed, have ovuliferous scales and bracts that usually are arranged spirally around a central axis (FIGURE 2). In most species, two ovules are present on each ovuliferous scale close to the cone axis and each can produce a viable seed. The scales at the base and tip of the cone may not produce viable seed and the proportion of scales which can produce viable seed varies by species.

The size and shape of the cone and ovuliferous scale will influence seed morphology, particularly size and shape. When a seed is removed from an ovuliferous scale one can see the depression in which the seed sat and the impression of the seed wing. Reference is often made to the upper (**abaxial**) and lower (**adaxial**) surfaces of tree seed. The lower surface of the seed is in contact with the ovuliferous scale below it while the upper surface is free from attachment to an ovuliferous scale. In most seed, a raised junction or lip can be seen where the upper and lower surfaces of seed meet. It is along this junction that the seed coat will split, initially at the **micropyle**, to allow the radicle to emerge.

The seed wing structure develops from the ovuliferous scale for species in the **Pinaceae** family. For yellow-cedar and redcedar (in the **Cupressaceae** family) the seed wing is derived from the outer portion of the **integument**, which also produces the seed coat, and is a more integral part of the seed. Complete dewinging should not be performed on western redcedar or yellow-cedar as extensive damage to the seed coat could result.

Anatomical Details

A summary of the character, function, and occurrence of the common cell and tissue types is included as a reference to terminology used in the text (TABLE 1, page 4). The two most common cell types in conifer seed are **parenchyma** cells and **sclerenchyma** cells. Parenchyma cells are generally unspecialized, thin-walled and often contain **chloroplasts**. Sclerenchyma cells are thick-walled cells that provide support. The major tissue types are the vascular tissues: **xylem**, which transports water and nutrients, and **phloem**, which transports **photosynthate** from areas of production (leaves) to areas that utilize it (apices and growing areas). The **epidermis** or outer surface layer is generally important in regulating water and gas exchange. Other tissues such as **pith** and **cortex** are present, but these are mainly composed of parenchyma cells. Additional anatomical details on these cell and tissue types can be found in classic plant anatomy texts such as Esau[15] and Fahn[16].

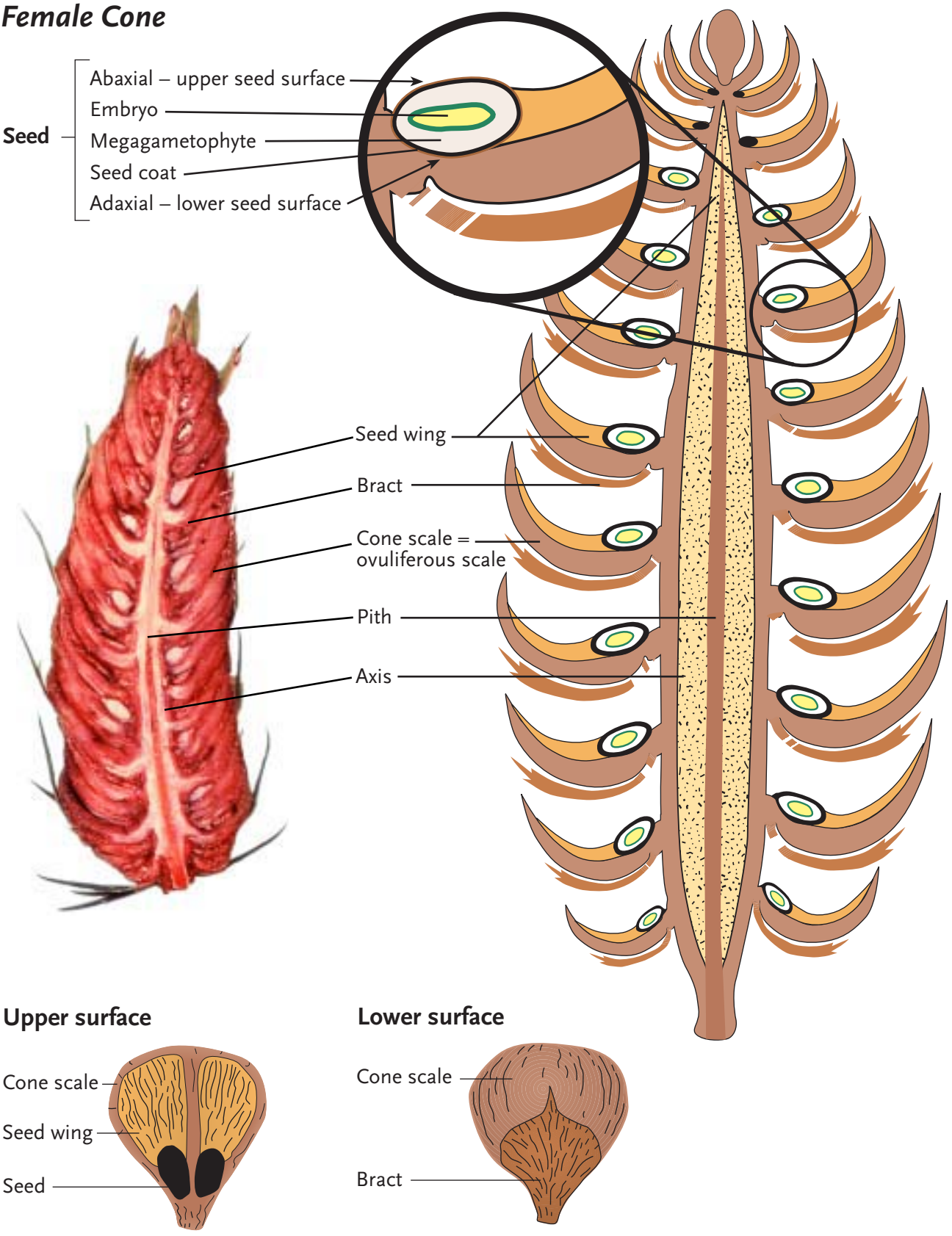

FIGURE 2

A longitudinal section of a typical cone found in the Pinaceae family with details of the upper and lower surfaces of an ovuliferous scale.

Table 1 **Characteristics, function, and occurrence of cell and tissue types found in the seed**

Cell type	Characteristics	Function	Occurrence
Parenchyma ***'unspecialized cells'***	• cells alive at maturity • variable shapes • thin cell walls • capable of division and expansion	• photosynthesis • storage • wound healing	• cortex • pith • xylem and phloem • megagametophyte • seed coat
Sclerenchyma ***'support cells'***	• thick, lignified cell walls • dead at maturity • elastic properties	• support by providing hardness and rigidity	• seed coat (middle layer) • xylem and phloem
Tissue type	**Characteristics**	**Function**	**Occurrence**
Xylem ***'water and nutrient transport'***	• complex tissue of many cell types • lignified, thick-walled **tracheids** dead at maturity • also living, thin-walled parenchyma • also thick-walled sclerenchyma, dead at maturity	• tracheids function in conduction of water and nutrients and also support • parenchyma function in storage • some parenchyma function in conduction	• in shoots, roots, and leaves
Phloem ***'sugar or photosynthate transport'***	• complex tissue with several cell types • living thin-walled **sieve cells** predominate	• sieve cells transport photosynthate • parenchyma functions in storage and lateral conduction • sclerenchyma provide support	• in shoots, roots, and leaves
Epidermis ***'surface layer or skin'***	• various cell types may be present • usually one layer of tightly packed cells • can be modified into guard cells • replaced by other protective tissue – **periderm**	• prevents water loss and microbial infection • mechanical support • guard cells function in gas exchange	• outermost layer covering shoots and leaves • not found in roots of conifers